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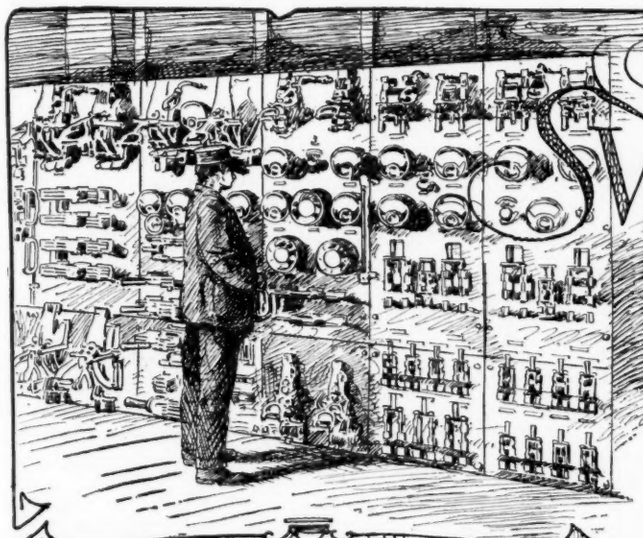


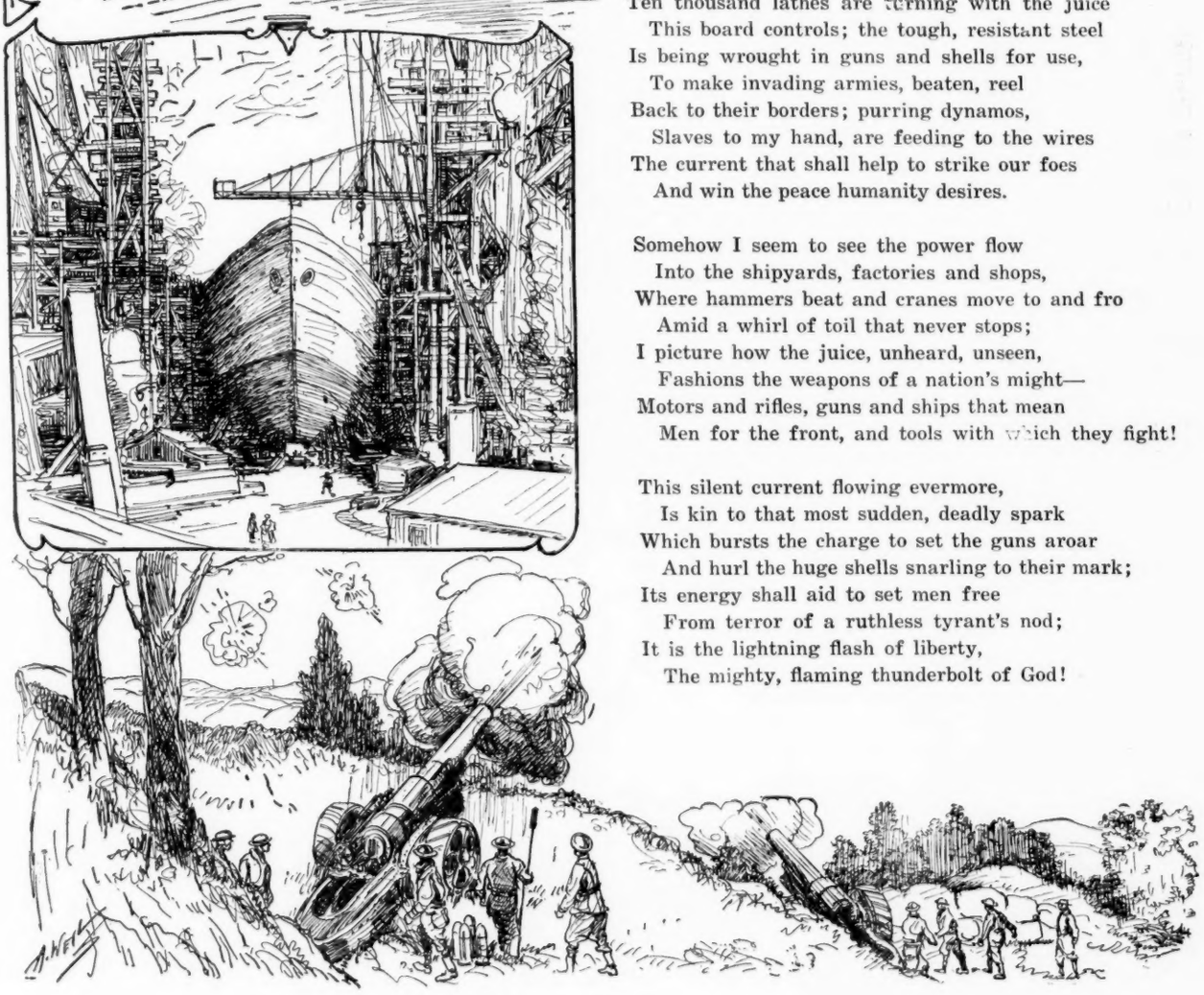
AT THE SWITCHBOARD IN WAR TIME

BY BERTON BRALEY

Ten thousand lathes are turning with the juice
  This board controls; the tough, resistant steel
Is being wrought in guns and shells for use,
  To make invading armies, beaten, reel
Back to their borders; purring dynamos,
  Slaves to my hand, are feeding to the wires
The current that shall help to strike our foes
  And win the peace humanity desires.

Somehow I seem to see the power flow
  Into the shipyards, factories and shops,
Where hammers beat and cranes move to and fro
  Amid a whirl of toil that never stops;
I picture how the juice, unheard, unseen,
  Fashions the weapons of a nation's might—
Motors and rifles, guns and ships that mean
  Men for the front, and tools with which they fight!

This silent current flowing evermore,
  Is kin to that most sudden, deadly spark
Which bursts the charge to set the guns aroar
  And hurl the huge shells snarling to their mark;
Its energy shall aid to set men free
  From terror of a ruthless tyrant's nod;
It is the lightning flash of liberty,
  The mighty, flaming thunderbolt of God!



A Few Facts About Water as the Operating Engineer Should Know Them

By CHARLES H. BROMLEY

This article is intended for the young operating engineer who is not a graduate of a college, technical school or technical course of study. It is for the young man starting in power plant work as most of us start.

WATER is capable of four states: Solid, as ice; liquid; vapor, as saturated steam and fog; gaseous, as superheated steam. As ice it weighs 57.5 lb. per cu.ft.; as liquid, 62.5 lb. per cu.ft. at 70 deg. F.; as saturated steam at atmospheric pressure, 0.0373 lb. per cubic foot.

There are five important temperatures of water as it concerns the engineer: At 32 deg. F. it congeals and becomes ice[1], and ice melts; at 39 deg. it is most dense, that is, it weighs more per unit of volume than at any other temperature; 62 deg. is the standard temperature commonly used in calculations involving the weight and volume of water; 70 deg. is the temperature widely used as standard for water for condensers, etc.; at 212 deg. and atmospheric pressure water evaporates into steam on continued application of heat and steam condenses to water on further loss of heat. For all practical purposes water is incompressible. From an engineering viewpoint perhaps the most important property of water is that it, like all true fluids, transmits pressure equally in all directions. This property is often referred to as

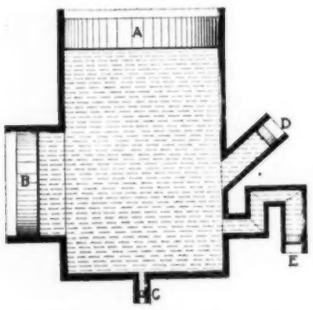


FIG. 1. THE PRESSURE OF WATER IS EXERTED IN ALL DIRECTIONS

Pascal's Principle: At any point or in any horizontal plane in a fluid at rest the pressure is equal in all directions.

Pressure exerted on a liquid in a closed vessel is transmitted to every part of the vessel and acts with the same force on all the surfaces of the vessel.

The piston *A*, Fig. 1, is 30 sq.in., *B* 20 sq.in., *C* 1 sq.in. *D* 10 sq.in., and *E* 8 sq.in. Neglecting the weights of the water and the pistons, also neglecting friction, put a pressure of 10 lb. on *C*. As *C* is 1 sq.in. in area, the pressure applied will be 10 lb. per sq.in. As the water is practically incompressible, a pressure of 10 lb. per sq.in. will be exerted in every direction. That piston *A* may hold back this pressure—that is, keep from moving up—a weight or total pressure equal to its area multiplied by the pressure tending to push it out must be applied. For *A* we must apply $30 \times 10 = 300$ lb.; for *B*, $20 \times 10 = 200$ lb.; for *D*, $10 \times 10 = 100$ lb.; for *E*, $8 \times 10 = 80$ lb. This principle is used in boiler-feed pumps, elevator pumps, hydraulic jacks, hydraulic presses, the small pump used for giving the boilers a hydrostatic test, etc.

Water weighs 62.5 lb. per cu.ft. Therefore every cubic foot "piled" on top of another increases the total weight of the water 62.5 lb. The total pressure on the bottom of the glass jar, Fig. 2, is $62.5 \times 3 = 187.5$ lb. *But not 187.5 lb. per sq.in.* The pressure per square inch is the total pressure divided by the area in square inches, or $\frac{187.5}{144} = 1.3$ pounds. There are $144 \times 12 = 1728$ cu.in. in a cubic foot. Therefore water weighs $\frac{62.5}{1728} = 0.03617$ lb. per cu.in. See how this checks out in the column of water in Fig. 2: $0.03617 \times (1728 \times 3) = 187.5$ lb. per cubic foot.

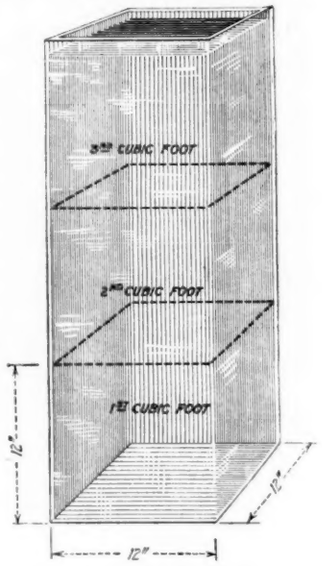
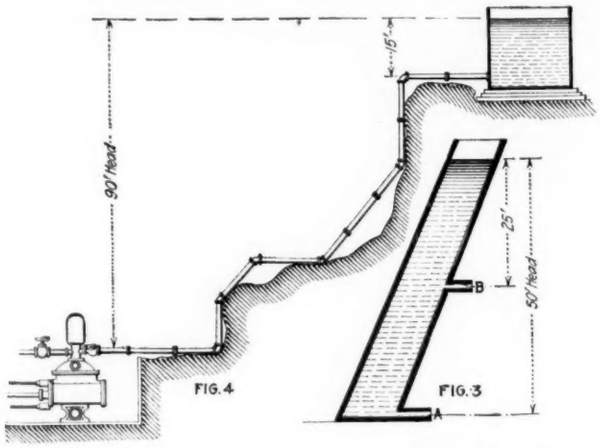


FIG. 2. THE FIRST CUBIC FOOT CARRIES THE WEIGHT OF THE OTHER TWO

A column of water 1 in. square and 1 ft. high weighs $\frac{62.5}{144} = 0.434$ lb. So to find the pressure in square inches created by a head of water, simply multiply the head or the vertical depth in feet by 0.434. Then the pressure per square inch on the bottom of the jar, Fig. 2, is $3 \times 0.434 = 1.3$ lb., which checks with the figure obtained in the preceding paragraph.



FIGS. 3 AND 4. THE HEAD IS ALWAYS THE VERTICAL HEIGHT OF THE COLUMN OF WATER

[1] If water is kept perfectly still, its temperature may get many degrees below 32 deg. before ice begins to form; but should it be kept still and its temperature get down, say, to 20 deg., it will freeze quickly if slightly agitated.

Head of water is always taken as the vertical height of the column of water. See Figs. 3 and 4.

The pressure per sq.in. at any point on the side of a vessel containing a liquid at rest is equal to the weight of a column of the liquid 1 sq.in. at its base and of a height equal to the distance between the given point and the surface of the liquid.

Thus in Fig. 4 the pressure where the discharge line enters the tank is $15 \times 0.434 = 6.51$ lb. per. sq.in. The pressure on the pump is $90 \times 0.434 = 39.06$ lb. per sq.in. In Fig. 3 the pressure at A is $50 \times 0.434 = 21.7$ lb. per sq.in., and at B, $25 \times 0.434 = 10.85$ lb. per square inch.

The textbooks say water should be lifted 34 ft. in a pipe in which there is a perfect vacuum. The explanation is that the atmosphere exerts a pressure of 14.716 per sq.in. and, as a column of water 1 in. square and 1 ft. high weighs 0.434 lb., the height of such a column which the atmospheric pressure will support is $\frac{14.7}{0.434} = 34$ ft. Of course water gives off a vapor which partly destroys the vacuum, and this and air leaks prevent the water from rising to this theoretical height. However, we see now why the tail pipe of barometric condenser should be at least 34 ft. long.

Carrick Furnace System

As the cost of coal is the largest single item of expense in the production of power, the type of furnace grate used is important. Many furnaces are equipped

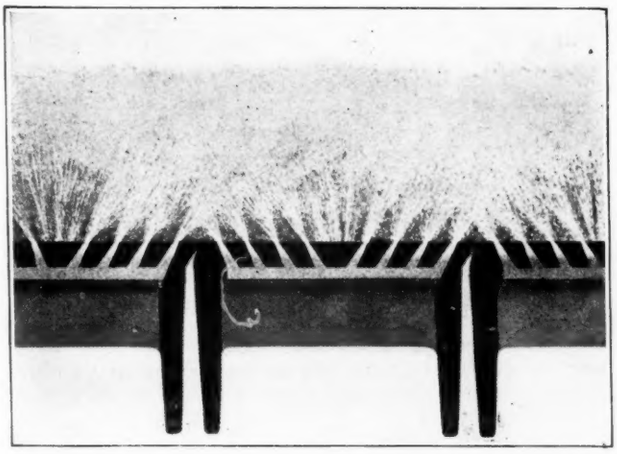


FIG. 1. SHOWING OPENINGS IN THE TUYERE PLATES

with grates that are not suitable for burning certain grades of fuel. Any furnace should be so constructed that the proper volume of air is supplied to the fuel through the grate. With this aim in view various types of grates and air-supply systems have been devised, among them being the Carrick furnace system, manufactured by the Carrick Engineering Co., 538 South Clark St., Chicago.

In the Carrick system there are three essentials—forced-draft apparatus, a special grate and a proper design of furnace. Air necessary for combustion is forced by a blower through ducts leading to the ashpit, and it then passes under pressure into the coal bed through openings in the tuyere plates of the grate. These air passages are oblique and nozzle-shaped, and are so arranged that the multitude of separate streams of air travel through them to the fuel bed. This is shown in Fig. 1, and the general design of the grate bar with the tuyere plates assembled is shown in Fig. 2, which also includes a top and bottom view of the tuyere plates. It will be seen that the air passages are

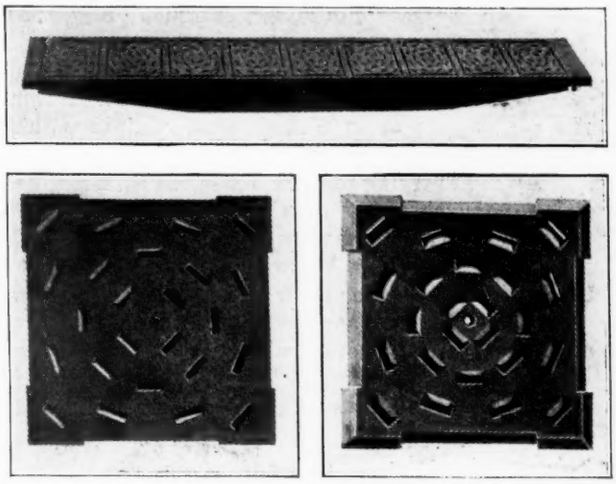


FIG. 2. TOP AND BOTTOM OF TUYERE PLATES, ALSO ASSEMBLED GRATE BAR

larger at the bottom than at the top, and this construction insures against clogging and fine grades of coal can be burned.

Fig. 3 shows this type of grate as applied to a return-tubular boiler, the grate being shown in position, and one method of directing the air to the ashpit, which in this case is through the bridge-wall, the air supply being controlled by a damper operated by means of a handle extended to the front of the boiler setting. In other designs the main air duct is installed below

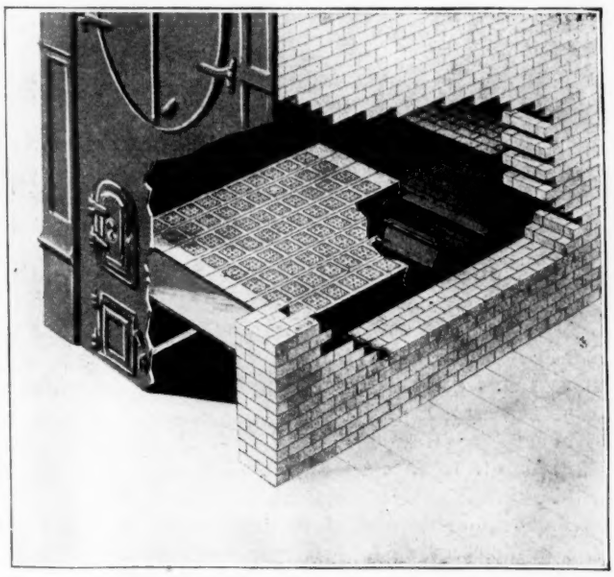


FIG. 3. CARRICK SYSTEM APPLIED TO BOILER FURNACE

the boiler-room floor and air ducts lead from it to each individual ashpit.

The furnace draft is automatically regulated for variations in steam pressure by means of a controller which operates a balance valve in the steam-supply line leading to the fan engine.

Use of Methane as a Fuel*

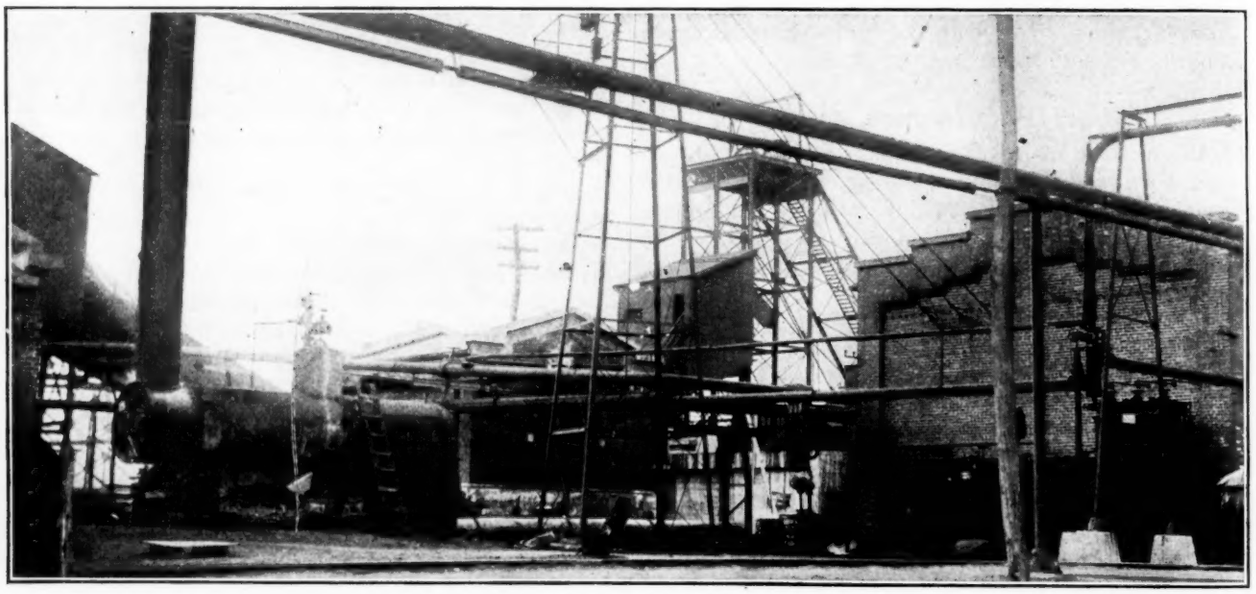
By GEORGE W. WILLIAMS

THE millions of cubic feet of methane which is drawn by fans daily from the anthracite mines, in order to make mining less hazardous, may possibly be harnessed, despite the contrary view of many experts, and utilized in a commercial way. The combustibility of methane is not disputed, but whether this terror of the mines, pure or in a mechanical mixture with air, can be put to use as fuel is a matter that men of thought and vision are trying to work out in the hard-coal fields.

Two big problems relative to the possibility of giving methane a commercial value are now in the hands of mine students in the Wyoming Valley. The first of these, and probably the more important, is to determine the value of the methane content of mine air. The second is whether the return air from mines, containing 1 per cent. of methane and less oxygen than pure air, can produce a greater heat for the coal consumed than can pure air alone.

At the Loomis colliery of the Delaware, Lackawanna & Western Co., at Nanticoke, Penn., there has been erected an experimental station that may quickly and without danger of contradiction decide the question of the commercial worth of methane. It is not the type of plant that denotes permanence, neither has it an expensive foundation. It does not give evidence of coal company lavishness. It does represent a purpose, however, and what it lacks in substantiality and cost is fully made up in the determination back of the motive—the earnest zeal for solving one of the unique mine questions of the century.

This experimental station was erected at the direction of W. W. Ingliss, vice president and general manager of the Delaware, Lackawanna & Western Co., and stands in close proximity to the big Loomis breaker. It takes form in a locomotive boiler fitted with a smoke stack about 30 ft. high. Fifty feet distant is the big



EXPERIMENTAL STATION ERECTED AT NANTICOKE, PENN., TO TEST AVAILABILITY OF METHANE AS A FUEL

Most problems of this sort are eventually solved through study and experiment, and it follows that any coal corporation sufficiently interested to go to the expense and trouble of almost public experiment must have found some fact in laboratory work on which to base expectation and hope.

Months ago Governor Martin Brumbaugh of Pennsylvania wrote to an official of the Delaware, Lackawanna & Western, Coal Department, and suggested that the millions of cubic feet of methane going to waste and the millions of cubic feet more left untapped in the earth be put to some practical use. That message did not fall on deaf ears, for out of it has grown, following long study and work in the laboratories of that company, a determination to test in some conclusive manner the possibility of commercially utilizing methane—a question that has enthusiastic champions and perhaps just as positive antagonists.

mine fan of the Loomis colliery, which for years has been throwing the impurities of the mine into the atmosphere. To conduct these to the boiler an airway has been built.

The natural operation of the fan would be to throw out its mixtures above the mouth of the feed line. To divert the course of such mixtures a smaller fan has been installed in the airway 6 ft. from the intake, and by this means a certain amount of air is shunted and forced to the base of the boiler. Thus instead of taking air from the atmosphere for the purpose of burning coal, the current comes from the fan drift; and here comes the chance to experiment with the first of the big questions to be determined—that of learning the value of the methane content of mine air, the plan being of course to consume or take advantage of the methane constituent of this air, which is about 1 per cent.

It is stated that the first experiment will be made with this equipment while connected with the mine

*From "Coal Age." Methane is marsh gas, or firedamp.

drift, and that after the value of the methane content of the air has been determined further tests will be made by obtaining the air supply from the atmosphere.

The principle of the experiment is plain. In determining the value of methane in the return air current a unit weight of coal will be consumed and the water evaporation noted. The equipment will then be changed in order that the air supply be obtained from the atmosphere, under which condition an equal unit of coal will be burned and the water evaporation noted for comparison.

At this point the second of the big questions presents itself. It is well known that the return air from the Loomis mine contains 1 per cent. of methane. As a matter of fact it contains less oxygen than is found in the atmosphere. Oxygen is the supporter of combustion, and in the return air from the mine oxygen is present in less degree than in atmospheric air. Whether the return air can produce more heat for less coal consumed than pure atmospheric air becomes then a most interesting matter.

Comparisons are always of interest. In the case of the Loomis experiments the existing facts may afford interesting study. Analysis of pure air, as all mine students know, shows the following: O, 20.93 per cent.; CO_2, 0.03 per cent.; N, 79.04 per cent. State reports show the analysis of Loomis mine air to be O, 20 per cent.; CH_4, 1 per cent.; CO_2, 0.07 per cent.; N, 78.93 per cent.

Will the return air, with 1 per cent. methane as shown in the foregoing analysis, and its 20 per cent. of oxygen, produce results equal to those secured when using pure air containing 20.93 per cent. oxygen?

The Loomis is one of the most gaseous mines of the Wyoming Valley. Two fans are constantly in operation drawing impurities from the underground workings. The larger of these draws off every 24 hours 3,451,680 cu.ft., or 77.6 tons, of methane. The smaller one throws off 2,462,400 cu.ft. each 24 hours, or 55.4 tons, making a total of 5,914,080 cu.ft., or 133 tons of combustible gas exhausted from this mine each day.

Just what will be the result of the Loomis experiments is problematical, but they bring forcibly to light the fact that a big company and capable men are just now groping in the darkness, as it were, on the methane question. While they have not as yet laid their hands on facts and conditions that indicate any revolution in the anthracite industry, they are thinking and working, and out of their earnest effort is certain ultimately to come definite conclusions as to the possibilities, positive and negative, of the great methane question.

Alarm To Show Fan Trouble

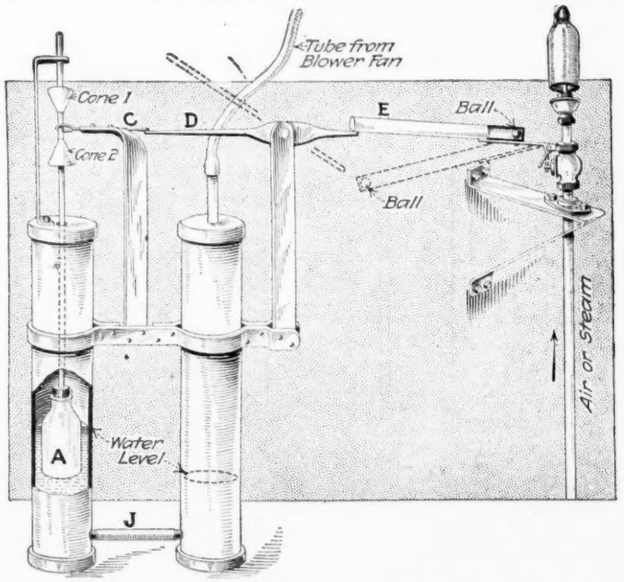
By W. F. Decker

The illustration shows an alarm that has been installed at the Mathiessen & Hegeler Zinc Co.'s coal mine at La Salle, Ill. This device has proved satisfactory, and the idea may be valuable to others whose conditions approximate those encountered at the La Salle operation.

In this particular installation the motor driving the fan derives its current from a line that also serves several other motors. The common source of energy is the main power plant of the company. In consequence, if the main circuit-breaker goes out, the fan motor as well as the other motors stop. Before the installation of this mechanical telltale the stoppage of the fan might not have been perceived until the regular rounds were made or word was received from the shaft bottom.

As may be seen from the diagram, the apparatus is simple and can be built by almost anyone. Two containers of equal size, or nearly so, are placed side by side and connected together near the bottom by the pipe *J*. Both containers are partly filled with water. The top of the one is connected to the pressure side of the fan and the top of the other is open to the atmosphere. A large water gage is thus formed.

On the water in the open leg of the device is placed the float *A* (in this case a tightly corked bottle), which carries a small rod that passes upward through suitable guides. Upon this rod are placed two cones, one pointing up and the other down. Between these cones and encircling the rod is the trip slide *C*, which is so arranged that an excessive movement of the cones either up or down will cause the rod *C* to move to the left.



DETAILS OF ALARM TO WARN OF FAN TROUBLE

Such a movement will trip the walking beam *D*, which will then rotate under the weight of the hollow lever *E*. This lever, which is attached to the lever of the whistle, contains a steel or iron ball. When the tube is in normal position, this ball rests against the end nearest the whistle. When the outer end of the lever is released from its support and swings downward, the ball rolls to its outer end, thus bringing sufficient weight into action to blow the whistle, which is under 120 lb. air pressure.

It will thus be apparent that so long as the fan runs at rated speed and the resistance of the mine is normal the surfaces of the water in the two containers will be at different heights, but practically steady, and the float *A* will support the cones at nearly a constant point. When for any reason, however, the fan stops or the resistance of the mine greatly decreases (as through short-circuiting of the air), the relative elevations of the water surfaces change. The float *A* will thus fall and the whistle will sound until the apparatus is reset.

Care of Heating and Ventilating Equipment—VI

By HAROLD L. ALT

This article describes the gravity one-pipe steam-heating system, its troubles and their remedies. Up-feed and down-feed. Packing valves. The packless-valve. Automatic air valves. Air-line valves. Sizes of pipe connections and risers.

THE simplest steam-heating apparatus to operate is the one-pipe gravity system with single connections to radiators through which the steam enters and the condensation leaves the heating unit. Air is relieved from the radiators by means of hand-operated or automatic air valves which discharge the air directly into the room, or the more unusual type which discharge the air into an "air line" pipe that

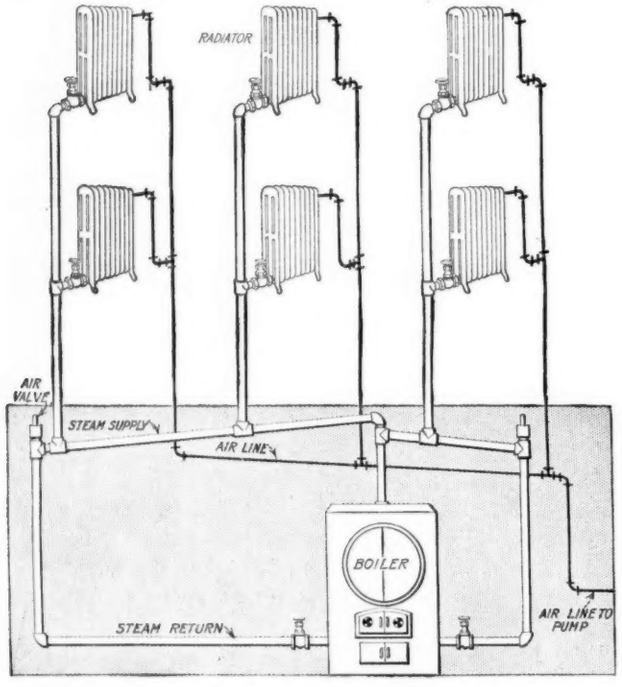


FIG. 1. TYPICAL ONE-PIPE SYSTEM WITH AIR LINE

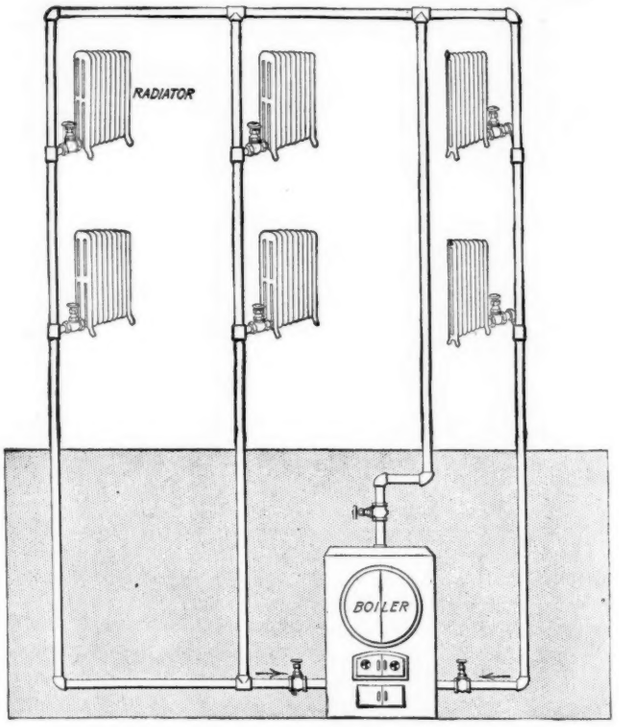


FIG. 2. DOWN-FEED OR MILLS SYSTEM OF PIPING

may ultimately open to the atmosphere at some remote and unobjectionable point or be connected to a vacuum pump that maintains a slight vacuum on the air line and relieves the radiators of air more rapidly. Fig. 1 shows a typical one-pipe up-feed system with an air line that may simply open to the atmosphere or be connected to an air pump. The one-pipe system may be arranged for either up-feed (in which steam is supplied and the condensate returns through one set of risers) or down-feed as in the Mills System shown in Fig. 2, in which all the steam is carried to the top of the building in one or more mains which supply the overhead distributing header, which in turn supplies the branches or down-feeding "risers." Either may have an air line or the ordinary air vents on the radiators, as desired. It may be remarked that the up-feed one-pipe system is usually limited to smaller installations and that in large installations the action is apt to be slow and noisy.

In the one-pipe system the operating engineer's chief trouble consists in keeping the radiator valves packed to prevent leakage and in maintaining the air valves in repair to prevent air binding or excessive escape of steam into the room. The stem packing of the radiator valve is a simple proposition, involving no great difficulty but considerable work, and the most satisfactory material for this purpose is asbestos wicking coated with a little graphite to allow tightening up of the packing without causing too much friction, making the valve hard to turn. Engineers who have operated systems fitted with such valves know that this repacking means no small amount of work during the year and that damage from water sometimes is almost impossible to prevent in spite of careful watching, because the radiator may be off at the time it is inspected and leaks may develop on cold days when radiators not used in mild weather are turned on and perhaps there is an increased steam pressure.

A superior type of radiator valve not heir to packing troubles is commonly termed a "packless" valve, in which there is a metallic partition between the steam space and the operating stem or a close-fitting sliding joint, thus making steam leakage impossible. In general, packless valves can be readily distinguished from packed valves by the heavier-looking construction of the bonnet, and in some the bonnet is extended up around the valve stem, concealing it entirely. There are many designs of packless valves manufactured, and the

alleged merits of each are set forth in publicity bulletins. Before passing from the subject it is desired to caution against the use of any form of valve that does not drain completely. Use an angle, gate or other straightway valve, because the seat of the ordinary globe valve forms a trap or dam in the line, causing a horizontal pipe to remain half filled with water, thus greatly interfering with the flow of steam to the radiator.

Valves for air relief are manufactured in a great variety of forms. In general, all automatic air valves operate on the thermostatic or the float principle or a combination of both principles. On hot-water radiators and in places where air needs to be vented only occasionally, valves requiring manual operation when air collects are used and preferable. The automatic air valve is intended to open and relieve the air from the radiator or piping system whenever it collects, and close again when steam or water reaches the valve. In eliminating the hand operation some other objectionable features appear, such as danger of clogging up from time to time as previously explained, by oil or sediment in the system, or failure to close when the steam or water enters, permitting leakage. As a result of improper adjustment they may have too much opening or be damaged by screwing down the adjustment too close.

Air-line valves are constructed along similar lines, the main difference being that the air and steam or water accidentally passing the valve instead of escaping into the room is discharged into an air line and damage is thereby prevented. Air lines are often favored for this reason and also sometimes added to gravity systems when they are too slow in heating up. In the latter case the air line is connected to a small vacuum pump, which is a great help to rid the system of air quickly.

Causes of Air-Valve Troubles

Most air-valve trouble is due to the small amount of movement obtainable between the open (or contracted) position of the valve and the shut (or expanded) position. The opening is easily clogged, and the smallest particle of grit lodging on the valve seat will prevent its closing tight. When the small opening becomes clogged, the portion of the radiation from which the air should be relieved by this particular valve will become airbound; in other words, the air occupies the space instead of the steam and unless relieved in some manner no amount of steam pressure will do more than compress the air slightly. When a radiator does not heat up, a simple test is to have two or three pounds of steam pressure on the line and listen near the air valve to see if air is being expelled. If no air is escaping, make sure that the supply valve is open; if no air can yet be detected, shut the supply valve and unscrew the air valve out of the radiator. If the air puffs out with a sudden rush, it shows that the air valve was not working and was holding back the air, but if the air does not rush out on the removal of the air valve, it indicates that there is no pressure on the radiator and that the trouble lies farther back. Whether an air valve is clear or not can be ascertained by simply placing the threaded end in the mouth and trying to blow air through the valve, for, of course, if air goes through the valve it is open, but if air cannot be blown through the adjustment should be changed or the passages cleared until air can be blown through.

If the adjustment is changed so as to allow the air to pass very freely, it is likely that the valve has been set so far from the seat that it will not entirely close with the small movement obtained by expansion when the steam reaches the vent, therefore, the adjustment should be opened up only until the air begins to blow through and not beyond this point, for of the two evils it is better to have a radiator fill with steam rather slowly on account of the more gradual expulsion of the air than to have it fill more quickly but with the air-valve spouting steam and dripping water continually afterward.

Unsatisfactory Adjustments

Where air-valve adjustment has been attempted perhaps several times and proper operation is not obtained, the trouble may be due to one or several causes. The most likely one is oil; the next, the float or expansion member may have been injured or else the float may be filled with water. Oil generally causes an air valve to fail to relieve air until opened up, and then it fails to shut off when the steam comes. Closing the valve after the steam strikes it results in the oil hardening in the valve opening as soon as the radiator cools off and then the next time steam is turned on the valve again fails to relieve the air and the radiator is airbound.

Injury to the expansion post or to the expansion float is usually caused by setting the valve too tight so that the expansion of the expansion post caused by the steam jams the valve against the seat and ruins it, or the expansion member is bent and spoiled. Heat alone will sometimes cause the expansion post to buckle "out of straight," in which case the valve will fail to operate. Where steam or water secures entrance to a sealed float, it usually results in the float failing to act. When difficulties beyond the matter of adjustment arise, it is usually cheaper to put on a new valve than to try to repair the old, as these valves are not expensive and the damage from water that one imperfect valve may cause or the inconvenience from air binding is much greater than the cost of several new ones.

Packing Air Valves to Prevent Leaking

One annoying difficulty often encountered with air valves is the dripping of water, drop by drop, when steam is on the radiator. This may occur when the setting of the valve is at the right point and when the interior parts are perfect, and unless the cap is removed and the source of this leakage is carefully noted it will probably be thought that the valve is faulty and allows steam to leak past. This, however, is not always the case, for the steam may be working up through the thread on the shell inside of which the adjustable part of the valve travels. To avoid this most valves have provision for a little packing beyond the bottom of the thread so that the seat, in screwing down, catches the packing in the thread and thus seals this joint.

Where oil in the system is the cause of the air-valve

troubles, get rid of the oil (as previously noted) and then clean the air valves by washing them in kerosene, benzine, or by boiling in soda and water. Be sure that the air valve is not left in a horizontal or inverted position. This may appear to be an unnecessary precaution, but valves are often found inverted or in some other improper position. Another case where water leakage will occur, usually in spite of the float which is supposed to prevent it, is when the radiator completely fills with water. In a one-pipe system this sometimes happens because in shutting off the radiator valve the spindle, which is surrounded by steam, is expanded to its limit at the steam temperature, but as the radiator cools the valve spindle contracts proportionately. Thus a valve that is shut down fairly hard when hot is not shut quite so tight when cold, and in a great many cases will allow a little steam to leak in under it. This results in a gradual filling of the radiator to the level of the air valve. Usually, under such circumstances the water will come out of the air valve—float or no float—and opening the radiator valve will give sufficient water-hammer to make one think the whole system of piping is going to be knocked to pieces.

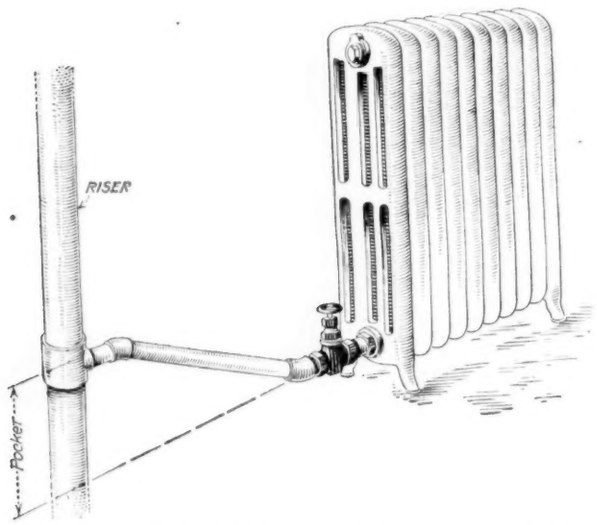


FIG. 3. PITCH OF BRANCH PIPE IN WRONG DIRECTION

This will occur with only one or two pounds steam pressure and higher pressures will intensify the trouble.

If the steam valve is only partly shut similar conditions result—the steam rushing in through the restricted valve opening, effectually prevents the passing out of the condensation and holds water inside the radiator. This is always accompanied by a gurgling and bubbling sound from the radiator and sometimes by a rattling of the radiator valve, with the steam valve and the lower part of radiator warm and the top portion cold. This water accumulation will occur just as readily on the top floor as on the first.

One way to empty a water-logged radiator is to bank the boiler fire until a slight vacuum forms in the system and then open the valve of the water-logged radiator, allowing the water to flow back to the boiler assisted by the vacuum. This treatment will usually stop water-hammer, which otherwise may last for half an hour or more. As the partial shutting off of a radiator valve on a one-pipe system will cause the radiator to fill with water, so a pipe connection that is too small will cause water-logging, water-hammer and gurgling. The sizes shown in Table I are ample, and no such trouble will be experienced if these sizes are used.

TABLE I. PROPER SIZES OF PIPE CONNECTIONS

Size of Radiator	Size of Runout and Valve, In.
Up to 24 sq.ft., inc.	1¼
Over 24 to 60 sq.ft., inc.	1½
Over 60 to 100 sq.ft., inc.	1½
Over 100 sq.ft.	2

On sizes of 25 sq.ft. or less it is sometimes possible to use a 1-in. valve and then enlarge the line to 1¼-in., although in best practice nothing less than 1¼-in. is used for one-pipe work. If the radiator branch is pitched in the wrong direction (toward the radiator as shown in Fig. 3), a water pocket is formed which will produce gurgling and water-hammer and interfere with the circulation of the steam and water. Just how serious this will be depends on conditions, such as the depth of seal, comparative size of pipe, etc. In order to determine the correct size for the horizontal pipe the simplest formula to use is:

$$\sqrt{1.25\,R} \div 9 = D$$

R = the equivalent direct radiating surface;
D = diameter of steam main;
1.25 = a constant adding 25% for mains.

Thus a system with 12,000 sq.ft. of radiators would require

$$\sqrt{1.25 \times 12{,}000} \div 9 = D \qquad \sqrt{15{,}000} \div 9 = D$$

$$Approx.\ 123 \div 99 = 14\text{-}in.\ pipe$$

For the risers the sizes shown in Table II will be ample to guard against any conflict between the steam and water flowing in the same pipe.

TABLE II. SIZES OF RISERS

	Up-Feed, Sq.Ft. Radiation	Down-Feed, Sq. Ft. Radiation
1¼-in.	60	90
1½-in.	80	120
2-in.	130	200
2½-in.	190	290
3-in.	290	340
3½-in.	390	590

A Difficult Welding Job

As an example of what is sometimes done with an oxyacetylene cutting or welding torch the following from the *Pacific Service Magazine* tells how the broken ends of an 8-in. pipe line were joined after being fished up from the bottom of the Oakland estuary.

This was as difficult a job as has ever been attempted in welding gas pipe. The ends of the pipe were brought together between one of the double pontoons and fastened with a home-made pipe clamp somewhat on the principle of a belt tightener. This rig held the pipe ends rigid, but the difficulty of welding was hard to overcome on account of the wash of every boat passing up and down the estuary. This same constant rolling of the pontoons made it a trial for the welder to hold the torch steady in cutting the ends. In welding it was necessary to go around the pipe, that is, make an upside-down weld, as it was impossible to turn the pipe. In doing this the welder's head was partly submerged in the water. That the job was accomplished was due to the persistency of some men.

The Electrical Study Course—Simple Efficiency Test for Shunt Motors

Gives the theory of a simple method for determining the efficiency of a shunt motor from its losses. A practical test is described and the theoretical deductions applied to it. Means for obtaining the temperature rise of machines are also discussed.

MANUFACTURERS of generators and motors make it a practice to test all such machines before they leave the factory, and among the tests made are determinations of efficiency and of temperature rise. The larger the size of the unit the more elaborate the test. Most of the methods of testing require special facilities, particularly those used when results of considerable accuracy are required, and no attempt will be made to describe these. There are, however, simple tests which give very satisfactory results when a high degree of accuracy is not required and which can be carried out without the use of any apparatus or instruments other than a voltmeter and an ammeter. A test of this kind for efficiency and one for temperature rise will therefore be presented, since they can be carried out at the expense of but little effort. The discussion will be limited to a consideration of shunt motors.

The factor that determines the efficiency of a machine is the sum of the losses within it. Consequently, if the value of the losses at any load is known, the efficiency of the machine at that load can be computed. This follows from the fact that efficiency is the ratio of output to input and that output is equal to input minus losses. Thus, if e were to represent the efficiency at an input W and L the losses in the machine at that input, we would have for that load, $e = \frac{W - L}{W}$, or if the efficiency is to be in per cent., $e = \frac{W - L}{W} \times 100$; and since the input W equals EI (where E is the line voltage and I the current input), we are dealing with known quantities if the value of L corresponding to that of W is determinable. For example, if we were to test a 5-hp. 115-volt motor, the normal current input at full load would be given on the name plate and would be about 40 amperes; hence we would have $W = 115 \times 40 = 4600$ watts, and if L watts were the corresponding loss, the efficiency at full load could be expressed by $e = \frac{4600 - L}{4600} \times 100$ per cent. In the same manner the efficiency at four-fifths of full-load current would be $e = \frac{(\frac{4}{5} \times 4600) - L}{\frac{4}{5} \times 4600} \times 100$, at three-fifths of full load current, $e = \frac{(\frac{3}{5} \times 4600) - L}{\frac{3}{5} \times 4600} \times 100$, and so on for any load. It therefore remains only to determine the value of L in each case, and the test is conducted for that purpose.

Before going on to explain the test, it will be well to briefly review the theory concerning the losses within dynamo-electric machines. It will be remembered that these may be divided into three general groups or classes—electrical, magnetic and mechanical. The electrical losses are usually referred to as the resistance or copper losses and are occasioned by the flow of current through the windings of the armature and the field coils. The magnetic losses are those known as the core or iron losses since they exist in the core—that is, the iron—of the armature; they are due to currents which are induced in the core and to the effects of hysteresis in it. Finally, the mechanical losses are those composed of the friction at the bearings, the friction of the brushes on the commutator, and air friction, or windage as it is called. To summarize, we have:

- Total loss
  - (a) Copper losses
    - (1) Armature-resistance loss
    - (2) Field-resistance loss
  - (b) Iron losses
    - (3) Eddy-current loss
    - (4) Hysteresis loss
  - (c) Mechanical losses
    - (5) Bearing-friction loss
    - (6) Brush-friction loss
    - (7) Windage loss

Taking up the individual losses one at a time, we find that the armature-resistance loss is equal to $I_a^2R_a$, where R_a is the armature resistance and I_a the armature current. Since the armature current varies with the load, the loss due to it will vary and will, moreover, vary as the square of the current. In a shunt machine the field-resistance loss may be considered to be constant; in a motor it practically is so; in a generator there will be slight changes due to regulation of voltage, but they may be neglected when only approximate results are required. The eddy-current loss is dependent upon the strength of magnetic field and the speed of the machine; the same is true of the hysteresis loss. The strength of the magnetic field of a shunt machine may be assumed to be constant, although this is not strictly so; in an interpole motor it is practically constant; in an ordinary shunt motor it decreases with increased load, and in a generator it increases if the voltage is kept constant. For the purposes of this test, however, it may be considered constant. The speed of the machine may also be taken as constant; in the case of a generator it is kept so by the prime mover, but in a motor it really decreases slightly with increase of load.

Since the magnetic field and speed are both nearly constant quantities, the core losses may be considered as not varying with the load. The friction losses are dependent upon the speed, which, as just stated, is practically constant, causing these losses to be so; the same holds true for the windage loss. On belted and geared machines there is a change in bearing friction with change of load, but it may be neglected. The mechanical losses are consequently also constant irrespective of change in load.

We therefore find that loss (1), namely, the armature-resistance loss, varies almost as the square of the load, but that all the other losses, from (2) to (7) inclusive, remain constant at all loads. That is, L may be con-

sidered as being made up of two parts, one of which is constant and the other variable, the latter being equal to $I_a^2R_a$. Then if the constant part of the loss be represented by K, we have $L = K + I_a^2R_a$. It therefore remains to find K for the machine in question, and to find the value of $I_a^2R_a$ for various loads.

When a motor runs at no load its entire input is used up in losses, which consist of the constant losses K and

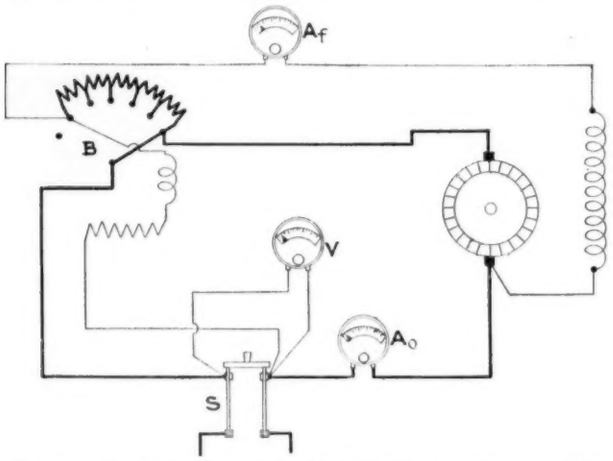


FIG. 1. CONNECTIONS FOR DETERMINING THE NO-LOAD INPUT AND FIELD CURRENT OF A SHUNT MOTOR

the variable loss $I_a^2R_a$. The value of $I_a^2R_a$ is, however, so small at no load that it may be neglected and the constant losses considered as being equal to the entire input. Hence, if we represent the no-load current by I_o and the line voltage by E_l we have $K = E_lI_o$. Although the variable loss is very small at no load, it rapidly increases with the load and the value of I_a for any load must therefore be known. Since the total current input is composed of the armature current and field current, we can obtain the former by subtracting the latter from the total current. That is, if we let I_t represent the total current and I_f the field current we have $I_a = I_t - I_f$.

An examination of the foregoing will show that in order to make the computations indicated the quantities that need to be determined are the normal voltage and full-load current, the no-load input, the field current, and the armature resistance. These are found in the following manner: The normal voltage and current are obtained from the nameplate marking. The no-load input is determined by running the motor at no load and observing the current taken by it and the voltage across it, using an ammeter connected into the circuit for the purpose and a voltmeter connected across the line. The field current is obtained by means of an ammeter connected into the field circuit. The armature resistance is computed from the value of the current flowing through the armature when it is at standstill and the voltage existing across its terminals at the time, using an ammeter and a low-reading voltmeter for the purpose.

The connections for the tests are shown in Figs. 1 and 2, the former of which shows those required to determine the no-load current, field current, and voltage, and the latter those used for the purpose of obtaining the armature resistance. The connections of Fig. 1 show an ammeter A_o connected into a part of the circuit common to both the armature and field, and another one, A_f, connected into the field circuit only so as to be able to measure the field current separately. A voltmeter V is connected across the switch S to measure the line voltage. All load is removed from the motor and it is then started. The indications of ammeters A_o and A_f and of voltmeter V are to be recorded while the machine is running under these conditions. Their readings will of course be the no-load current I_o, the field current I_f and the line voltage E_l.

For the test of Fig. 2 the lead a of the field circuit is removed from the armature terminal b and a bank of lamps r or other suitable resistance is connected into the armature circuit in series with an ammeter A. The switch S is then closed and a low-reading voltmeter V is connected across the armature terminals bc. The reading of the meters is obtained for various values of current, such as for full load, 75 per cent. of full load, and 50 per cent. of it. If we let I_r represent the current and E_r the corresponding voltage, we have, $R_a = \frac{E_r}{I_r}$ as the resistance of the armature in each case. The value of resistance to be used is the average of these results.

To find the efficiencies at various loads, such as 20, 40, 60, 80, 100 and 120 per cent. of normal, we proceed as follows: First we find the value of the constant losses from the expression $K = E_lI_o$. Then, assuming that normal full-load current is I amperes and normal voltage E volts, the efficiency at the loads chosen would be computed from the equation $e = \frac{W - L}{W}$, where $W = EI_t$ watts and $L = K + I_a^2R_a$ watts. The values of I_t would be 0.2 I, 0.4 I, 0.6 I amperes, etc., and those of I_a in each case $I_t - I_f$ amperes.

An efficiency curve is used to express the results graphically, and for this purpose the output in horse-

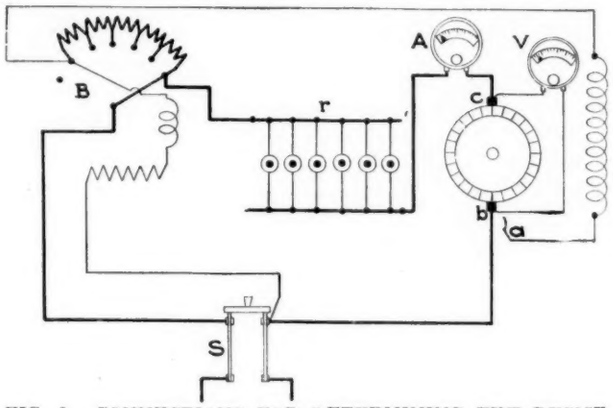


FIG. 2. CONNECTIONS FOR DETERMINING THE RESISTANCE OF THE ARMATURE OF A MOTOR OR GENERATOR

power and the corresponding efficiency in per cent. are used. The latter values have been determined in the foregoing and the former can be obtained from the watts output, $W - L$, by dividing by the number of watts in a horsepower, namely, 746, which would give,

$$\text{Output} = \frac{W - L}{746} \text{ horsepower.}$$

To illustrate the method, its application to an actual test will be gone through. Assume that we wish to plot the efficiency curve of a 5-hp. 115-volt shunt motor and that 40 amperes is the value of full-load current marked on its nameplate. Ammeters would be inserted into the

circuits as at A_o and A_f in Fig. 1, and a voltmeter connected across the lines as at V; switch S would be closed and the motor started by means of the starting box B. The ammeters and voltmeter would then be read and a record made of their readings. We will suppose that the reading of A_o, namely I_o, is 3.1 amperes, that of A_f, namely I_f, is 1.5 amperes, and that of V, corresponding to E_l is 112 volts. Then, since the constant loss is expressed by $K = E_l I_o$, we have, $K = 112 \times 3.1 = 347$ watts. The next step would be to open switch S, thus shutting down the motor, whereupon the connections would be charged to conform to Fig. 2 by removing

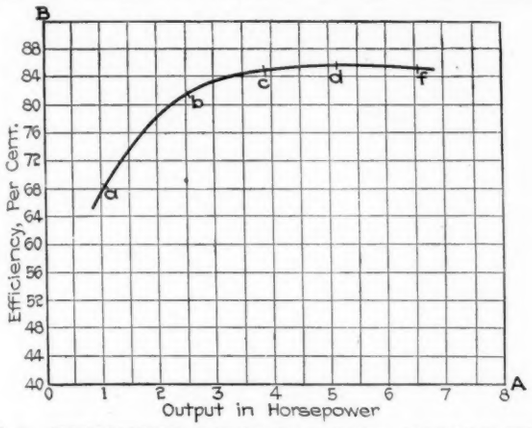


FIG. 3. EFFICIENCY CURVE OF A 5-HP., 115-VOLT SHUNT MOTOR AS OBTAINED FROM TEST UPON IT

field lead a from armature terminal b and inserting a suitable rheostat r and an ammeter A in the armature circuit. Closing switch S and bringing the starting-box lever to the running position would cause current to flow through the armature without making it rotate. The current would be adjusted to about 40 amperes (its full-load value) and voltmeter V would be connected across the armature terminals bc; the two meters would then be read simultaneously and their readings recorded. The current would then be reduced to about 30 amperes and another set of readings be taken, following which the current would be further reduced to about 20 amperes and a third set of observations taken. The readings of A would give the value I_r and those of V the value of E_r. We will suppose the values found to be those given in Table I.

TABLE I. OBSERVATIONS FOR DETERMINING RESISTANCE OF ARMATURE OF 5-HP., 115-VOLT MOTOR

Reading No.	Armature Current, Amperes I_r	Voltage Across Armature, Volts E_r	Armature Resistance Ohms (Computed) $R_a = \frac{E_r}{I_r}$
1	42	7.55	0.18
2	28	5.60	0.20
3	18	4.50	0.25
Mean	...	....	0.21

From the values found for the no-load input, the field current, and the armature resistance, the efficiencies at loads ranging from 25 per cent. of normal current to 25 per cent. greater than normal would be calculated. The data, as they would be compiled, are given in Table II. The entries in column 1 are assumed values of load current, those in column 2 the normal voltage of machine. Column 3 contains the values of armature current corresponding to the assumed load currents; they are found by subtracting the field current from the load currents of column 1; since the field current was previously supposed to have been determined as equal to 1.5 amperes, this is the value that is to be subtracted. The entries in column 4 are the variable losses corresponding to the assumed load currents, and are obtained by multiplying the squares of the values in column 3 by the armature resistance, which was found to be 0.21 ohm, as determined from the readings supposed to be entered in Table I.

TABLE II. DATA FOR COMPUTING EFFICIENCY OF A 5-HP. 115-VOLT MOTOR AT VARIOUS LOADS

1 Total Current I_t	2 Normal Voltage E	3 Armature Current $I_a = I_t - I_f$	4 Variable Loss $I_a^2 \times R_a$	5 Total Loss $L = K + I_a^2 R_a$	6 Input $W = EI_t$	7 Output $\frac{W-L}{746}$	8 Efficiency $e = \frac{W-L}{W} \times 100$
Amperes	Volts	Amperes	Watts	Watts	Watts	Horsepower	Per Cent
10	115	8.5	15	362	1,150	1.06	68.5
20	115	18.5	72	419	2,300	2.52	81.8
30	115	28.5	171	518	3,450	3.93	85.0
40	115	38.5	311	658	4,600	5.28	85.7
50	115	48.5	494	841	5,750	6.58	85.4

Column 5 gives the values of the total loss, obtained by adding the variable losses of column 4 to the constant loss K, the value of which was previously computed as being equal to 347 watts. The input at the various load currents is then computed by multiplying these currents as given in column 1 by the normal voltage, column 2, and the results are entered in column 6. In column 7 are entered the horsepower output corresponding to the load currents. They are obtained by subtracting the losses recorded in column 5 from the inputs of column 6 and dividing the result by 746. Finally, the

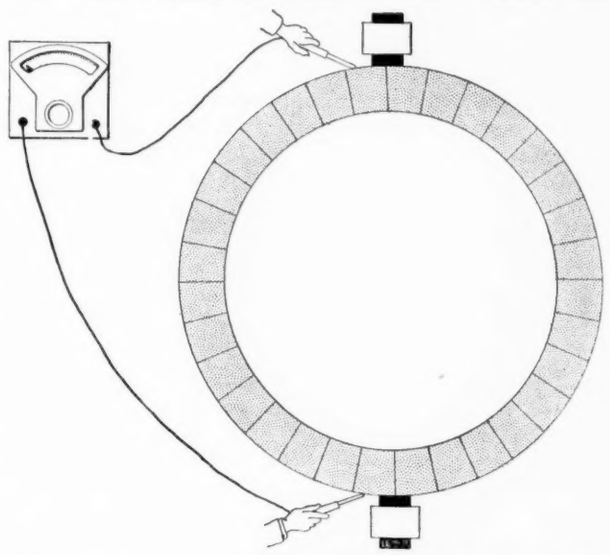


FIG. 4. SHOWING VOLTMETER LEADS HELD TO COMMUTATOR SEGMENTS TO OBTAIN ARMATURE RESISTANCE

efficiencies at the various inputs would be figured from the values appearing in columns 6 and 5 by means of the equation $e = \frac{W - L}{W}$ and the results entered in column 8.

The next step would be to construct the efficiency curve, for which purpose the quantities appearing in column 8 would be plotted against the corresponding values in column 7. The result would be that illustrated in Fig. 3, in which the results of column 7 are laid off in a horizontal direction from the line OB according to the scale marked on line OA, and those of column 8 are laid off in a vertical direction from the line OA according to the scale marked on line OB. The points

at which the corresponding horizontal and vertical measurements meet, indicated at *a*, *b*, *c*, *d* and *f*, are joined by a curved line as shown, and this is known as the efficiency curve. From it the efficiencies for any loads intermediate between those for which calculations have been made can readily be determined by laying off the load horizontally and finding the point at which it crosses the curve, the vertical measurement of which will be the efficiency.

Determining the Temperature Rise

There are two methods of determining the temperature rise of machines. One is to make direct measurements by means of a thermometer and the other to compute the rise from the increase in resistance due to it. In the former method the machine is loaded and allowed to run until its temperature becomes stationary. The temperature of the room in which the machine is situated is then taken, following which the temperature of the machine is measured. Usually, the temperature of three parts is determined; namely, that of the field coils, the armature and the commutator. To do so the bulb of the thermometer is held against the part whose temperature is to be measured, and covered with waste or rags to confine the heat. It is allowed to remain so until the thermometer reading attains a maximum when the temperature is recorded. When there is sufficient space between turns of the winding, the thermometer bulb is inserted in it instead of being held on the surface. The temperature rise of the various parts is the difference between the temperature they attain and that of the surroundings. Thus if T is supposed to represent the temperature rise, T_a the temperature attained, and T_r that of the room, we have $T = T_a - T_r$.

The second method of determining temperature rise can be applied to the armature and field windings but not to the commutator. To apply it, the resistances of the armature and of the field before and after the test must be obtained. It is well known that the resistance of practically all metals increases with rise in temperature and this holds true of copper, which is the metal of which the armature and field windings are made. It has been found by experiment that the resistance of copper increases by 0.42 per cent. for each degree Centigrade rise in temperature. Hence, if the temperature rises T deg., the resistance will increase $0.42 \times T$ per cent. For example, if we suppose R to be the increase in resistance of a circuit made of copper, due to rise in temperature, R_r its resistance before being heated, and R_a that when hot, then we have first, that $R = R_a - R_r$ and, secondly, that $R = R_a - R_r = 0.42\ T$ (per cent. of R_r) $= 0.0042\ TR_r$. If R_a and R_r are known, the value of T can be computed since, from the preceding, $T = \dfrac{R}{0.0042R_r}$.

Strictly speaking, 0.42 per cent. is the percentage of resistance at *zero* deg. that a copper conductor increases for each degree rise in temperature. That is, $R_a = R_0 + 0.0042\ T_aR_0$ and $R_r = R_0 + 0.0042\ T_rR_0$, where R_0 represents the resistance of the conductor at 0 deg., and T_a and T_r have the same values as previously assigned to them. From these expressions it can be shown that $T_a = \dfrac{R_a(1 + 0.0042T_r) - R_r}{0.0042R_r}$. The value of T_r is of course measured with a thermometer; having computed T_a, their difference is $T = T_a - T_r$. However, for the differences in temperature involved in electrical machinery the expression derived in the preceding paragraph will give results almost identical with those obtained with the one just adduced, and it is the one commonly used.

The resistance of the armature is obtained by passing current through it and measuring the voltage across it in exactly the same manner as that described in the case of the efficiency test, except that the resistance of the armature winding only is to be determined; that is, the brush-contact resistance is to be excluded in this case. The connections are those shown in Fig. 2, but the voltmeter leads are to be touched to the commutator bars directly under the brushes, as shown in Fig. 4, instead of to the brushes or brush-holders as shown in Fig. 2. The segments across which the voltage is measured should be marked for identification. The field resistance is determined by measuring the field current and the voltage applied and dividing the former into the latter.

A set of readings for the resistances are to be taken when the machine is "cold"; that is, when the time elapsed since last being in operation has been sufficient to allow the machine to cool down to the temperature of the surroundings. After the readings have been taken the connections for normal operation are restored, first placing an ammeter in the circuit as at A_0 in Fig. 1. The motor is then started and load put upon it—full load if possible. It is allowed to run in this way for about an hour, within which interval it will generally have reached its ultimate temperature. It is then stopped and the measurements for armature and field resistances repeated. When taking those for the armature, the voltage drop should be measured across the same commutator segments as before, these having been marked for identification, as previously described. It is of course understood that the segments are again to be directly under the brushes.

Computing the Hot and Cold Resistances

The hot and cold resistances R_a and R_r are computed from the readings of voltage and current obtained, and their difference R found. From this the temperature rise is derived from the expression $T = \dfrac{R}{0.0042R_r}$. The temperature-rise determinations by the resistance method will usually give considerably higher values than obtained by the thermometer method, owing to the fact that the latter are surface temperatures only, which are lower than those within the windings themselves. The resistance method, therefore, more nearly gives the average temperature rise throughout the mass of the winding.

The problem of the previous lesson dealt with a grounded armature, the data given being that a drop of 8 volts existed across the brushes when current was passed through the armature, and that the readings of a voltmeter connected between the frame and segments 12 and 13 of the commutator shown, were 0.3 volt and 0.2 volt respectively. It was required to find what voltages existed betwen the frame and all the other segments of the commutator and to determine in which coil the ground existed. Neglecting those short-cir-

cuited by the brushes, there are 16 coils in each circuit of the armature. Since the voltage across them is 8 volts, the voltage across each coil must be $8/16 = 0.5$ volt. Consequently, this value must be added to those given as existing between the frame and segments 12 and 13 in order to determine the voltage between the frame and the adjacent segments; namely, 11 and 14. For segments 10 and 15 twice 0.5 volt must be added, for 9 and 16 three times 0.5 volt, and so on. As pointed out in the preceding lesson, the voltage between segment 20 and the frame will be the same as that between 13 and the frame, and likewise that for 21 will be the same as found for 12.

From the foregoing we would find the following voltages betwen the frame and the segments specified: Segments 1 and 32, 5.8 volts; 2 and 31, 5.3 volts; 3 and 30, 4.8 volts; 4 and 29, 4.3 volts; 5 and 28, 3.8 volts; 6 and 27, 3.3 volts; 7 and 26, 2.8 volts; 8 and 25, 2.3 volts; 9 and 24, 1.8 volts; 10 and 23, 1.3 volts; 11 and 22, 0.8 volt; 12 and 21, 0.3 volt; 13 and 20, 0.2 volt; 14 and 19, 0.7 volt; 15 and 18, 1.2 volts; 16 and 17, 1.7 volts. The ground might be either in the coil between segments 12 and 13, or in that between segments 20 and 21. In order to determine which, the armature would have to be turned slightly and another test made, as explained in the preceding lesson.

A 10-hp. 220-volt shunt motor takes a normal full-load current of 38 amperes. The resistance of its armature is 0.3 ohm and its field current 1.0 amperes. The constant losses amount to 400 watts. Find the efficiency at 25 per cent., 50 per cent., 75 per cent., 100 per cent. and 125 per cent. of full-load current.

Large V-Notch Meter

The accompanying illustrations show an interesting meter installation that was made for the Pennsylvania Railroad Co. to meter the High Ridge water-supply system at New Florence, Penn. The Yarway meter has a stroke of 18 in. and is said to be the largest in this country. It measures 5,000,000 gal. of water per 24 hours. It will be seen that eight V-notch weirs, Fig. 2, are mounted in parallel, the height of the water being

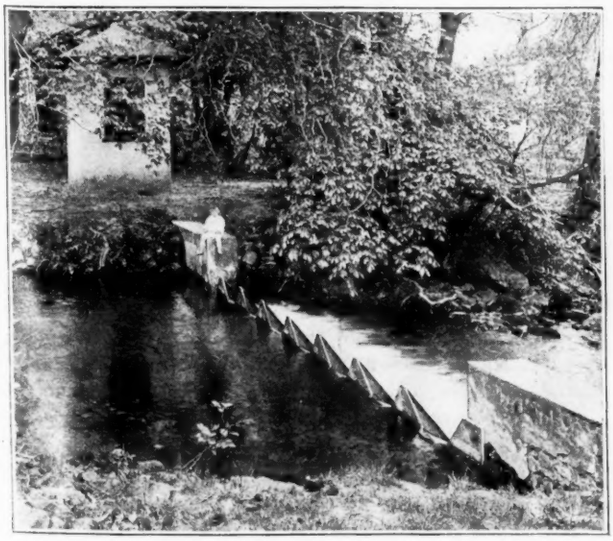


FIG. 1. EIGHT V-NOTCH WEIRS AND METER HOUSE

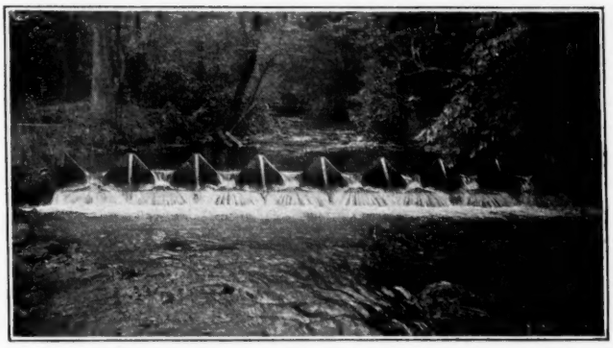


FIG. 2. V-NOTCH WEIRS FROM DOWNSTREAM

measured by the float in a float chamber which communicates with the stream and is installed in a separate meter house, shown in Fig. 1. In addition to the chart record the instrument is provided with a standard clock-type integrater.

The illustrations are used through the courtesy of Superintendent C. A. Spencer. The meter was installed in January, 1917, and has given entire satisfaction.

Largest Single-Piece Boiler Head

The largest boiler head ever made from a single plate is illustrated herewith. It is 13 ft. in diameter and is $1\frac{3}{16}$ in. thick. A specially constructed car was necessary to take it from the Lukens Steel Co., where it was designed, to the yards of the Portland Shipbuilding Co. Scotch boiler heads of this size and type are being

A THIRTEEN-FOOT ONE-PIECE BOILER HEAD

used on the "Sea Bird," "Pelican," "Crane," and the other steam trawlers of the East Coast Fisheries Co. now building at Portland, Maine.

The figure of the man at the right of the illustration gives a good comparison between his height and the diameter of the head.

Twenty-Seven Thousand Dollar Saving in Manhattan Building Plant

By using Edison off-peak service during the summer months, substituting motor-driven elevator pumps for inefficient steam pumps, installing a feed-water heater and a stoker, a saving of 2700 tons of coal out of an average annual consumption of 4500 tons is anticipated. The saving in operating expense is expected to reach $25,000 to $30,000 per year.

THE owners of the Manhattan Building, one of Chicago's old-time office structures built in 1893, have awakened to the fact that a power plant improperly designed and inefficiently operated is a decided medium of waste. Suggestions from the Fuel Administration started an investigation which disclosed poor mechanical conditions and an operating efficiency far below par. The plant had been a constant violator of the city smoke ordinance and needed revamping all the way through. The advantages of the Edison off-peak contract were investigated and it was decided to use this service principally during the six warmer months of the year. H. M. Pulsifer undertook the work, and from results already obtained, remarkable savings are indicated.

Conditions of the Power Plant

The Manhattan Building is a 16-story structure covering an area of 65 x 150 ft. It is exposed the long way on the east and west sides. The power plant consisted of two 300-hp. water-tube boilers, operated alternately. The boilers were hand-fired. Owing to low headroom, the conditions were unfavorable for good combustion. The feed-water heaters were clogged with scale and oil, and the mechanical conditions generally were poor. The generating machinery consisted of one 100-hp. and one 150-hp. high-speed automatic engine, driving 110-volt direct-current generators. These units were used alternately to light the building. On the average about 10,000 kw.-hr. was supplied monthly in summer and in winter the average load per month approximated 16,000 kw.-hr. In addition there were several compound and simple duplex pumps, the former operating five high-speed hydraulic elevators and the latter taking care of the house water and the usual auxiliary services required in a building of this kind.

Fuel requirements ranged from 325 tons of coal during the summer months to 425 tons a month during the winter, with a corresponding expense for engineers, firemen, supplies, ash disposal, maintenance, etc. Sufficient exhaust steam was available to heat the building, containing 22,000 sq.ft. of direct radiation in weather as cold as 5 deg. above zero without the use of live steam. In warmer weather the exhaust escaped to atmosphere and was not utilized advantageously even to heat the feed water.

Because of the investigation started by the Fuel Administration, a complete new elevator and house-pumping equipment was ordered on July 15 last. The elevator pumps consisted of two 310-g.p.m. and two 110-g.p.m. triplex pumps belted to 40- and 15-hp. motors respectively. The pumps are now installed and are all under automatic control, being started and stopped as necessary in handling approximately 50,000 gal. of water per hour. The high efficiency that could be maintained indefinitely was the reason given for the selection of this type of pump. For the house service a motor-driven centrifugal pump was selected.

A contract was signed with the Commonwealth Edison Co. which offered attractive rates on the agreement that the service would not be used during the daily peak load throughout November, December, January and February. As this is the period of the year the owner is obliged to operate his own plant for heating, the limitations fitted the case perfectly. The electrical energy required can be generated as a by-product of the heating steam, with considerable gain over supplying the two services separately.

In the month of October the electrical load of the Manhattan Building was 25,000 kw.-hr. Including demand and energy charges—in other words, the total cost for electrical energy—the rate averaged 2c. per kw.-hr. The average summer load runs about 22,000 kw.-hr. per month, as compared with the foregoing value, and the winter load runs considerably higher, usually ranging from 30,000 to 40,000 kw.-hr. per month. However, the building operates its own plant during the six colder months.

Saving During First Month's Central-Station Operation

Carload express shipment of the pumps made it possible to put them in operation by Aug. 15. The electrical service was shifted over to the central station and the first full month's operation showed a saving approximating $3000 over the former average cost during the summer months for fuel, labor and supplies. Allowing for the coal to operate a small auxiliary boiler for hot water and other uses throughout the building and considering the quantity of fuel used by the central station to supply the service, it would appear that a net saving of 250 tons per month had been made or, in other words, an aggregate saving of 1500 tons in the six months between May 1 and Nov. 1.

During the two months before the opening of the heating season the general power equipment had been overhauled and rearranged. The old 150-hp. engine now pulls the two generators which operate in series on the three-wire plan, delivering 115-230-volt current for lighting and power for the motor-driven pumps. The generating equipment has been in service since Nov. 1, and the absorption by the heating system of all exhaust steam with an outside temperature of 50 deg. gives evidence of the efficiency of the arrangement.

Although roughly it is the intention to use central-station current throughout the six months from May 1 to Nov. 1, and to operate the plant for the other six months, there may be some slight variation in this

plan. For example, in mild winter weather when but little steam is necessary for heating, Edison service will be drawn on to some extent. The building will manufacture just enough electrical energy to furnish exhaust steam for heating, and the remainder of the power required will be drawn from the central-station's mains, excepting, of course, during the peak hours from 4 to 8:30 p. m.

There has been no time as yet for an adequate test, but conservative estimates by the engineer indicate an average saving of 200 tons of coal per month over former requirements. This would mean a winter term saving of 1200 tons and a total year's saving of 2700 tons out of 4500 tons formerly used. With coal at $6 per ton this is a large item for one building.

The entire program for improvement has not been completed. A new feed-water heater will be installed shortly, and preparation is being made for the installation of an inclined coking stoker under one of the boilers. In the old setting, because of limited headroom, the grates, which were 4½ ft. deep by 12 ft. wide, had been set 20 in. from the tubes. The steelwork under the columns in the floating foundation had been so extended as to prevent grates the full width of the boiler being placed any lower. The new furnace was made 6½ ft. wide and 7½ ft. deep. For this width it was possible to excavate between the steel grillages in the foundation. It is to be carried to the front somewhat in a semi-dutch-oven equipped with a suspended straight tile arch 4½ ft. long. The combustion space expands out to the full 12-ft. width of the boiler, giving about 9 cu.ft. of furnace volume per square foot of grate. From the grate surface to the lower tubes the average distance approximates 5 ft. It is also proposed to change from horizontal to vertical baffles in the boiler, but the final decision has not been made. From this arrangement much higher economy and smokeless operation are expected.

One 50-kw. and two 75-kw. direct-connected generating sets have been ordered to make the power-generating equipment more flexible and modern. These units will displace the present belted outfit as soon as they can be obtained.

Including the pumps previously mentioned, the foregoing are the only considerable items of new purchase, in addition to the labor cost of reconstruction, foundation, rearrangement of steam and exhaust lines, electrical connections, etc. The coal storage was increased from 70 to 200 tons capacity. The heating system has been equipped with vacuum returns and the house water supply has been rearranged and improved. To prevent excessive air leakage, 662 windows have been fitted with metal weather strips. A feature that will contribute to the saving is the reduction of the power-plant payroll to about 50 per cent. of the former annual amount. As estimated by the engineer the monetary saving should range from $25,000 to $30,000 per year. These figures approximately cover the investment in the power plant.

It is gratifying to report that the chief engineer is under a profit-sharing contract whereby his alertness and ability earn for him a substantial share of the economies effected. This, of course, is as it should be, and if the plan were more generally followed, similar savings might be reported in numerous plants where equal opportunities exist.

Erecting a Large Vertical Generator

By N. L. REA

The erection of large vertical generators presents interesting problems to the erecting engineer. A recent case presented several new problems, and in addition several new ideas were tried.

THE machines that were installed in a certain plant were approximately 37 ft. in diameter over all and the revolving field was 34 ft. and some inches in diameter. A one-piece shaft and thrust bearing on top of the generator further complicated the erection, especially as the waterwheel runner would support only the shaft and the total revolving weight was 275 tons with two 150-ton cranes for handling.

The armature frames were shipped in four sections, less punchings and windings; the revolving-field spider was in two pieces, and the cast-steel field rim in four sections. The punchings were assembled and the quarter sections wound while the wheel was being assembled. The waterwheel runner sat on the bottom ledge of the wheel casing and carried the weight of the shaft. It was found that the runner would spring enough so that the shaft vibrated during blasting or when construction trains or the cranes were moved. This vibration was sufficient to interfere with the plumbing of the shaft.

A rectangular harness was therefore made around the shaft, which supported the inner ends of four long jacks. These jacks were made of 2- or 3-in. iron pipe, bolts, nuts and plate washers, and seated against the pit liner and the shaft at equidistant points. This arrangement stopped the vibration as the jacks were at the top of the pit liner several feet above the waterwheel guide bearing.

As soon as the shaft was plumbed properly, the generator assembly was started. The shaft diameter reduced just above the top of the field hub fit, with several feet of uniform diameter above this reduction. We had provided a large cast-iron spool for this fit. This spool was skeletonized and made with an easy fit on the shaft and shoulder so that it could be readily turned. A reinforced and braced wooden arm was fastened to this spool to make a tram that would extend over the armature location. The outer end of this arm carried an adjustable pointer for use in leveling and centering the armature.

This tram also had a lever attached to the spool for turning, to eliminate, as far as possible, disturbing the pointer. The foundation pads, twelve in number, were set approximately in their proper location by means of the big tram, and then the four quarters of the armature were assembled and bolted together. The top sur-

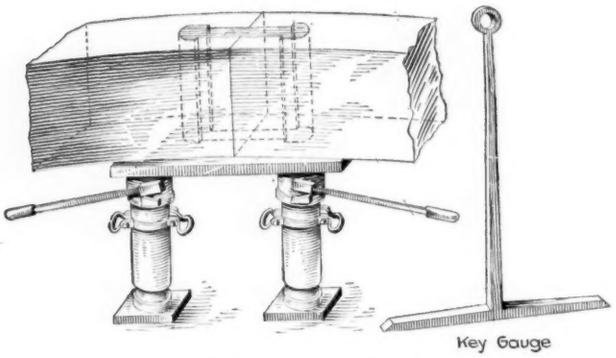
face of the armature was then leveled and centered with the tram.

This leveling was easily accomplished, as the foundation plates were equipped with jack-bolts and cup plates to set on the concrete under these jack-bolts. The foundation bolt holes had been partly filled with grout before the armature quarters were assembled; this permitted tightening the foundation bolts against the jack-bolts and locking the armature in place, after it was properly located. Of course allowance was made for the amount the waterwheel runner would be raised when adjusted to the running position. The setting was then checked by a 22-in. Y-level equipped with a very sensitive bubble and a special target. This arrangement was so accurate that three men could check within fifteen thousandths of an inch in 37 feet.

The foundation plates were then grouted with a half-and-half mixture and the joint coils installed while the grout was setting.

Meanwhile the revolving field was partly assembled on the floor; that is, half of the spider and two quarters of the rim were bolted together and the dumb-bell links shrunk in. A brief description of the method of shrinking these links may be of interest.

The keys were in two sections, a top and bottom each about 15-in. deep, and each piece was properly marked for its joint. Before the pieces of the rim were bolted



ARRANGEMENT FOR PLACING KEYS IN FIELD RIM

together, the proper end of each key was passed through the slot as a final check on the clearances. A gage, shown at the right of the illustration, was then made $\frac{1}{64}$-in. longer than the total length of the joint key slot between the shoulders. The keys were slowly heated in a wood fire until this gage was an easy fit between the shoulders, wood being used to obviate the scaling caused by coal or coke. The gage was kept lying on the field rim between tests to insure constant temperature. The illustration shows the arrangement of the joint for installing the keys. The bottom surface of the rim is used as a brake surface, therefore the keys should be flush. Experiment showed that a 14-mil (14/1000-in.) shim under the ends of the bar outside the keyway was just about right. This let the bottom key drop through a distance of 14 mils when hot, and the cross-shrink was enough to bring the key flush when cold. The two jacks were used to bring the sections parallel. The hot bottom key was then lifted by two long eye-bolts and entered in the slot. The keys had two holes through the web about midway between the top and bottom. Two men standing on opposite sides of the rim caught iron bars in the holes, these bars resting on wood blocks, and held the hot key while the eye-bolts were removed. The outer ends of these bars were then raised slowly and evenly until they tripped out of the holes and allowed the key to drop through to the supporting bar of its own weight. The key was then sledged slightly to insure its seating properly. The same procedure was followed in placing the top key, which was seated on the lower one, the shrinkage coming at the top where it did not cause any trouble.

The foundation pads had an extension which carried, alternately, hydraulic brakes and cast-iron supporting pads. These pads were arranged to take shims between their top surface and the field rim, to carry the revolving weight, when working on the thrust bearing. The grout having set properly, the field assembly was started. As the first step the six brake cylinders were replaced by six supporting pads borrowed from the next machine and all pads were capped with the proper shims. The two halves of the revolving field were then lowered in turn on these pads, care being taken to prevent the field striking the shaft or armature and to insure the rim joint coming midway between the two supporting pads. There was ample clearance as the poles had not been assembled.

The halves were then carefully worked toward each other, till the hub bolt holes lined up and the bore just cleared the shaft. Preparations were made for quickly shrinking the joint keys and bolting up the hub bolts. The shaft and runner were then raised high enough, with the crane, to match the field halves and held until the hub was pulled up and the joint keys shrunk in. The hub bolts were then removed a few at a time and heated in boiling water for a shrink fit. Experience proved that boiling was better and safer than heating by fire. The bolts were easier to handle and were, of necessity, all of the same temperature. From rough figures this scheme gave about 20,000 lb. fiber stress on the bolts.

Heating hub bolts with fire is dangerous as the bolts may have wide variations in temperatures with corresponding variations in fiber stress. The writer has seen hub bolts that showed evidence of stretching caused by tightening when too hot.

The crane was then released and the total revolving weight supported by the field rim and spokes. Of course this work was bound to move the shaft more or less, so the thrust deck and upper bearing was assembled, using the rabbet fit on the top of the armature frame as a reference. The thrust deck was assembled and adjusted from this fit. The top guide bearing was then placed in position and the thrust bearing assembled ready for adjustment.

A large motor-driven screw-jack was then placed on top of the thrust deck, the total revolving element lifted, the shims removed, and the thrust bearing adjusted to give the proper wheel clearances.

The problems on this installation were caused principally by the large diameter of the generator and the heavy weights. The station was equipped with two 150-ton cranes, but the spread of the cranes themselves, as well as the generator dimensions, prevented using both cranes. Then, too, the large motor-driven jack was much safer than a crane and gave slower and more uniform movements when making adjustments.

Controlling Efficiency of Combustion

By E. A. UEHLING

THIS ARTICLE INDORSED BY

U. S. FUEL ADMINISTRATION

As combustion is a chemical process, it can be diagnosed and controlled properly only by chemical apparatus. Various forms of such apparatus are mentioned and their uses are explained.

TO DETERMINE whether combustion in the furnace of a steam boiler is being carried on with the desired degree of efficiency the following apparatus is essential: (1) Equipment for making proximate and ultimate analyses of the coal; (2) a bomb calorimeter; (3) a hand gas analyzer; and (4) a recording and indicating CO_2 meter.

Every engineer should know the proximate analysis of his coal; that is, the percentages of fixed carbon, volatile combustible matter, moisture, ash and sulphur. He should also know the ultimate analysis; that is, the percentages of total carbon, hydrogen, oxygen, sulphur and ash. Without this knowledge he cannot calculate with any degree of accuracy the percentage of excess air, the free oxygen contained in the flue gas or the heat loss up the chimney. If the coal supply comes from one mine or even from the same coal field, it will answer to have an ultimate analysis made once every three or six months; but whenever there occurs a change in the source of supply, an ultimate analysis of a fair average sample is necessary. A proximate analysis should be made at least monthly, including a calorimeter test for the heating value. Not only are such analyses very desirable for the information of the operating engineer, but they are of the greatest value to the manager and proprietor as a check on the quality of coal received.

Samples Should be Sent to Chemist for Analysis

Since an engineer is not supposed to be a chemist and no operating engineer has the time to make his own analyses, the samples must be sent to a professional chemist for analysis. It would therefore be out of place to describe here the equipment required for analyzing coal. It is up to the engineer, however, to see that fair average samples of the coal are taken and properly reduced for the chemist. Instructions for doing this will always be gladly furnished by the chemist employed to make the analysis.

The most variable constituent of coal is the moisture content, due principally to variable weather conditions while on the way from mine to destination. Much of this moisture is lost in gathering and preparing the sample for the chemist, so that the chemist's analysis rarely gives the full moisture content of the coal as used. It is therefore advisable to make a moisture determination on every shipment suspected of containing an abnormal amount of moisture. This is very easily accomplished to a close degree of approximation by weighing out a sample of from 25 to 50 lb., crushing it to the size of a hazelnut or smaller, putting it into a shallow pan or tray, and setting it over the boilers or in some other moderately hot place. After 24 to 48 hours the moisture will be practically all driven off. The weight of the moist coal minus the weight of the dry coal, multiplied by 100 and divided by the weight of the wet coal will give the percentage of moisture.

The information obtained by the use of coal weighers and water meters can serve only as a general control over the combined operation of all the boilers; unless the composition and physical condition of the coal and its heating value are also taken into consideration, the engineer will frequently suffer blame unjustly. It therefore behooves every engineer to keep himself posted on the quality of the coal he is using, not merely as a weapon of self-defense when wrongfully accused of inefficiency by the records, but because without this information he is unable to judge cause and effect correctly.

Every manager should see to it, and every intelligent manager does see to it, that the engineer is kept posted on the composition and heating value of his coal, not merely as a matter of justice, but for the purpose of enabling him to operate more intelligently and consequently more efficiently.

The Orsat a Useful Apparatus

The hand gas analyzer, commonly called the Orsat apparatus, is a very useful and desirable apparatus, and every engineer should be in possession of one. It is very simple, and no special chemical knowledge is necessary to manipulate it successfully. If intelligently and consistently used, it gives very valuable information. The function of the hand gas analyzer is to determine the chief constituents in the products of combustion; namely, CO_2, O, CO and N. CO_2, O and CO are abstracted by absorption and measured in the order given, and what remains is set down as nitrogen. The gas may also contain appreciable amounts of combustible hydrocarbons, especially if combustion takes place in a relatively cool combustion chamber or one not large enough to give the necessary time for complete combustion; but these constituents are difficult to determine and are therefore rarely ascertained. CO_2 and O are quantitatively interdependent; if the percentage of CO_2 is high, the percentage of O is necessarily low, and vice versa. CO_2 is a reliable index to the amount of excess air used, and hence to efficient combustion. The presence of an appreciable quantity of CO indicates incomplete combustion. If the composition of the fuel is known, the percentage of excess air can be readily calculated by the simple formula

$$\textit{Percentage of excess air} = \frac{2100}{CO_2(1 + 3H)} - \frac{100 + 238H}{1 + 3H}$$

in which CO_2 represents the percentage of carbon dioxide in the flue gases and H the weight of available hydrogen per pound of carbon in the coal burned. Therefore, if the percentage of CO_2 is known, it is possible to ascertain the all-important factor, excess air, and there is no other way of ascertaining it.

Any competent engineer can, by the methodical use of an Orsat apparatus, very materially improve the

economical operation of his boilers; but it takes much time and requires close attention to get the best results, especially when a number of boilers are involved. Sporadic determinations of the principal constituents of the flue gas are of very little value. The composition of any sample of gas taken promiscuously depends much more on where the sample was taken, in its path from furnace to chimney, and when it was taken relative to the time of firing, than on the average combustion efficiency of the furnace and boiler from which it was taken. Such an analysis may therefore be quite misleading, for at best it shows the composition of the gas produced at the moment the sample was taken and might have been quite different if taken a few minutes sooner or later. The continual changing of composition of the gas and the close attention and the large tax on the engineer's time make the effective use of the Orsat burdensome; and as its infrequent use is of relatively small value, the thoughtful and progressive engineer will look about for a more rapid and reliable means for controlling combustion.

The gas sampling tank was introduced for the double purpose of reducing the labor and attention required, and of getting more reliable information for controlling the work of the firemen. Its function is to collect an average sample of the products of combustion from a given boiler over a definite period of time, generally over the entire shift. This procedure reduces the number of analyses necessary to be made to one, two or three a day per boiler, according to the number of shifts run in twenty-four hours. In a plant operating eight boilers, for example, a minimum of eight and a maximum of twenty-four gas analyses would be made per day.

Time Required to Make the Analysis

If the sampling tank is properly connected and handily placed the contents can be analyzed and the tank refilled with water in from ten to fifteen minutes. It will therefore take from one and a quarter to two hours per shift to make the analyses. This must be done promptly at the change of shift, or some provision must be made so that gases of the succeeding shift will not become mixed with those of the preceding shift. Someone must be deputized and held responsible for the proper sampling and the correct analysis of the gases produced by each fireman and boiler.

A resourceful engineer will no doubt find means to overcome these and other difficulties that will confront him in an earnest endeavor to get maximum boiler efficiency with the aid of a sampling tank and an Orsat apparatus. This system of control, however, has two very serious defects, which cannot be overcome. First, a sampling tank does not collect a true average sample of the gases passing the sampling tube; and second, even a true average sample does not necessarily represent correctly the combustion efficiency of the boiler sampled.

Sampling tanks are supposed to draw gas at a uniform rate, due to an automatically regulated suction head. In fact, they do not do so, because the suction head necessarily decreases as the draft against which the sample is drawn increases. The stronger the draft the less gas will flow to the tank per minute; on the other hand, the stronger the draft the larger will be the volume of gas that flows through the boiler. Therefore a sampling tank cannot draw a correct average sample of the gas produced.

Furthermore, supposing the sample to be a correct average of the gas produced, the average analysis may be a long way from showing the correct average combustion efficiency. Two firemen producing the same average analysis may vary as much as 20 per cent. in their combustion efficiency. To illustrate this point, let us compare the combustion efficiencies attained by two firemen A and B, as shown by the analyses of the gases produced by each, collected in sampling tanks drawing the gases at a uniform rate during the whole shift. Let us further assume that both attained complete combustion (the analyses showing no CO) and that each sample contained 11 per cent. of CO_2, which, on the face of it, would indicate that A and B are equally efficient. Such a conclusion, however, may be far from true, because no fireman can maintain an absolutely unvarying percentage of CO_2.

Determining the Economical Result

Suppose that fireman A produces gas showing from 6 to 16 per cent. of CO_2, and that fireman B produces gas showing from 9 to 13 per cent. of CO_2. The average is the same for both, since $\frac{16 + 6}{2} = 11$ and $\frac{9 + 13}{2} = 11$. But how about the economic result? The heat carried up the chimney by the dry gases may be calculated by the formula

$$\textit{Heat lost in flue gases} = \left(0.24 + \frac{58.46}{CO_2}\right) \times T$$

in which CO_2 represents the percentage of CO_2 in the flue gases and T the difference between the temperature of the escaping gases and the temperature of the air in the boiler room, in degrees F. This formula shows the heat loss in B.t.u. per pound of carbon burned, and while it does not give all the heat wasted, it does represent the bulk of the waste.

In the case of firemen A and B, suppose that $T = 500$ deg. F. Then, while A is making 16 per cent. of CO_2, the loss of heat in the flue gases is $\left(0.24 + \frac{58.46}{16}\right) \times 500 = 1947$ B.t.u., and while making 6 per cent. of CO_2 it is $\left(0.24 + \frac{58.46}{6}\right) \times 500 = 4992$ B.t.u. The average loss is 3469 B.t.u. While B is making 13 per cent. of CO_2 the loss is $\left(0.24 + \frac{58.46}{13}\right) \times 500 = 2369$ B.t.u., and while making 9 per cent. of CO_2 it is $\left(0.24 + \frac{58.46}{9}\right) \times 500 = 3368$ B.t.u., or an average loss of 2869 B.t.u.

Comparing these averages, it is seen that A wastes $3469 - 2869 = 600$ B.t.u. more than B, corresponding to $600 \div 2869 = 0.209$, or 20.9 per cent., more than B. Yet the information from the sampling tank and the Orsat would show that A is as good a fireman as B. This combination has the further deficiency that the information, even if it were reliable, leaves the fireman groping in the dark, dependent on his judgment alone for getting results. The only thing in favor of this system of control, if properly carried out, is the spirit of rivalry that may be engendered among the firemen.

The function of the CO_2 recorder is to make an autographic record of the percentage of CO_2 contained in the flue gas as it is produced. This enables the engineer to scrutinize the combustion performance of every boiler for every minute and get after the fireman or apply whatever other remedy may be necessary to obtain the desired result. The promptness with which this information is imparted and its completeness of detail add greatly to its value. It is something to be able to tell the firemen on Monday morning that they collectively did very well last week as per information from the coal weigher and the water meter, or that they did poorly and must improve. It is something more to be able to go to each fireman every morning and tell him that he attained good, bad or indifferent combustion efficiency yesterday, according to the information derived from the sampling tank and Orsat. This knowledge enables the engineer to establish a friendly rivalry for efficient firing.

The Second Method Much Better

The first method of control, however, leaves the engineer in the dark as to the individual efficiency of his firemen, as well as to the economic performance of his individual boilers. It is simply a wholesale control. The second method is much better, inasmuch as it is an approximate check on each boiler and fireman; but it gives the engineer no clue as to the cause of high or low average CO_2. Low CO_2 may be due to defects in the boiler setting (air infiltration) over which the fireman has no direct control, or it may be due to uneven firing, to allowing the fire to burn too thin before replenishing, to wasting time in cleaning fires, etc. The alert engineer will ferret out some of these causes and the intelligent fireman will in time learn how to produce a higher percentage of CO_2; but he is going it blind, and can improve his record only by cut-and-try methods. The effect of any change he makes does not show except as in his report next morning, obscured in his average for the day before.

Certainly, the economic operation of steam boilers can be, and has been, very markedly improved by both of these methods of control, when supplemented by the pyrometer and the draft analyzer; but it is very doubtful whether maximum combustion efficiency can be attained, much less maintained, by either of them, even if supplemented by the proper physical instruments.

Appearance no Guide to Combustion Efficiency

Any experienced fireman can tell by the appearance of his fire and combustion chamber, with a fair degree of certainty, whether he is getting practically complete combustion, but not one in a hundred can tell whether he is burning his coal with 25 or 100 per cent. of excess air; in other words, combustion efficiency can be ascertained only by chemical means. And because of the continuous variation in the conditions affecting combustion, it is necessary that the percentage of CO_2 be continuously indicated in plain view of the fireman so that he can see how well he is doing all the time, and it must be continuously recorded so that the engineer can see, whenever he may wish to do so, what each of his firemen did.

The continuous indicating and recording CO_2 meter, which indicates at the boiler front and records in the engineer's room, serves the double purpose of guide to the fireman and control for the engineer—not merely a general control of a day's performance, but a detailed control of every minute of it. The engineer may say to a fireman, "Your record for yesterday was bad, for you averaged only 8½ per cent. of CO_2, whereas your mates are averaging 11 to 13 per cent., and I expect you to do the same." But it makes quite a different impression if he says: "Look here, John; take a squint at your record. At 9:30 you allowed your CO_2 to go down below 6 per cent. before replenishing the fire, and then only brought it up to 10.25 per cent. again at 11:15. Now, at 2:30 and 3:15 you got the CO_2 up to 14 per cent. Why can't you get it there every time you replenish your fire? Furthermore, it took you nine minutes longer to clean your fire than it took Pat and Jim. You will have to do better than that, John. I will be back in a few minutes and show you how." With such detailed information as the CO_2 recorder gives, an experienced and alert engineer can quickly instruct a fireman how to watch the CO_2 indicator so as to attain and maintain maximum combustion efficiency.

Controlling Combustion Efficiency

Combustion efficiency is the prime factor in boiler efficiency, and it can be effectively controlled by the continuous indicating and recording CO_2 meter; but it is not the only factor. High boiler efficiency cannot be secured unless the absorption efficiency is also maintained at a high level. To be able to diagnose absorption efficiency, it is necessary to know the temperature of the gases on leaving the boiler, the percentage of CO_2 contained in them, and the approximate rate of driving. A pyrometer in the uptake and a differential draft gage between the furnace and the damper are necessary to obtain the required information. A differential draft gage between the ashpit and the furnace is also very desirable and useful, though not absolutely necessary. A draft analyzer that can be set to indicate either boiler or furnace draft will answer for both.

The recording CO_2 meter is the only instrument which, when properly installed and looked after, will by itself give reliable and most valuable information. In combination with the pyrometer and the differential draft gage it gives all the data necessary for attaining and maintaining maximum boiler efficiency.

Systematic Boiler-Room Operation

By Albert A. Straub

Steam boilers, as they are now being installed in the larger steam plants, are usually equipped with steam-flow meters for indicating and recording the output of the boiler, and draft gages to indicate and record conditions prevailing in the furnace, loss of draft in the moving gases over the tubes and with the underfeed stoker to indicate and record pressure at which air is supplied to burn the fuel. By proper study and intelligent application of data so obtained, it is feasible to devise a method of operation for steam-boiler plants, whereby the degree of judgment which the fireman and operators are required to exercise is reduced to a minimum. Their duties resolve themselves more to the application of the data supplied and to the manipulation of the units under their care to correct for small irregularities which are bound to arise in operation and from

which, as yet, it has not been possible to eliminate the personal factor when using coal as fuel.

In order to better illustrate the case in point and the system devised, application of the method to a specific installation is herewith given. The installation is a central generating station in which we can say are installed twenty water-tube 822-hp. boilers which, when equipped with eight retort underfeed stokers and burning coal of 13,000 B.t.u. as fired, will have characteristic operating and efficiency curves, as shown in Fig. 1.

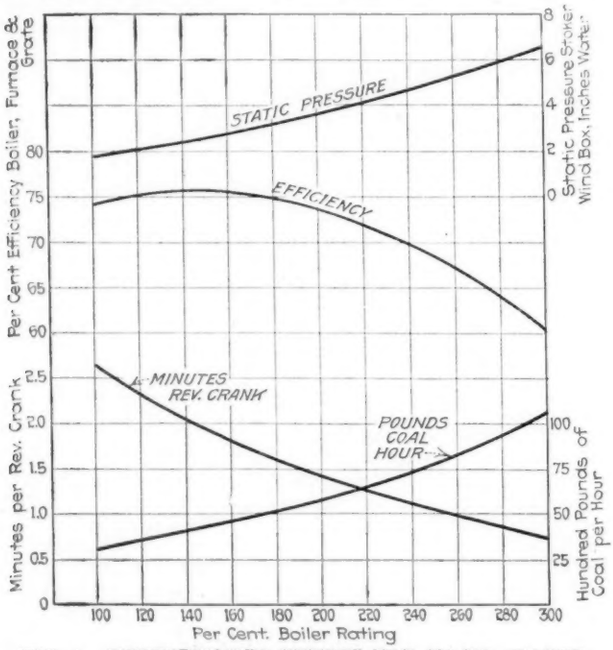

Per Cent Efficiency Boiler, Furnace & Grate
Static Pressure Stoker Wind Box, Inches Water
STATIC PRESSURE
EFFICIENCY
MINUTES REV. CRANK
POUNDS COAL HOUR
Minutes per Rev. Crank
Hundred Pounds of Coal per Hour
Per Cent. Boiler Rating

FIG. 1. PERFORMANCE CURVES FOR 822-HP. WATER-TUBE BOILERS EQUIPPED WITH UNDERFEED STOKERS

The steam consumption of the generating apparatus and plant auxiliaries is such that the relation between the plant output in kilowatts and output and rating of boilers can be graphically shown by a series of lines, Fig. 2 (Norman G. Reinicker, *Power*, Sept. 21, 1915).

BOILER-ROOM OPERATING LOG

Time	Load, Kw.	No. Boilers Operating	Per Cent. Rating	Inches Static Stoker Windbox	Steam-Flow Meter Reading Lb. per Hr.
12–1 a.m.	23,000	9	160	2.7	39,400
1–2	19,500	7	170	2.9	42,000
2–3	15,000	7	135	2.3	33,300
3–4	14,000	7	125	2.1	30,800
4–5	16,000	7	140	2.4	34,500
5–6	29,500	12	155	2.7	38,200
6–7	45,000	18	155	2.7	38,200
7–8	59,000	18	205	3.7	50,500
8–9	61,500	18	215	4.0	53,000
9–10	56,000	18	195	3.5	48,000
10–11	53,500	18	190	3.4	46,900
11–12	49,000	18	170	2.9	41,900
12–1 p.m.	42,000	18	145	2.5	35,800
1–2	62,500	18	215	4.0	53,000
2–3	52,000	18	180	3.2	45,400
3–4	53,000	18	180	3.2	45,400
4–5	64,500	18	225	4.2	55,500
5–6	75,000	18	260	5.2	64,000
6–7	67,500	18	230	4.3	56,800
7–8	54,500	18	190	3.4	46,800
8–9	51,500	18	180	3.2	43,400
9–10	43,500	18	150	2.6	37,000
10–11	37,500	15	150	2.6	37,000
11–12	30,000	12	155	2.7	38,200

Although the load curve of a central generating station generally does change somewhat in its characteristics from day to day throughout the week, the characteristic is usually the same for the same day of the week, neglecting general increments or decrements in the load. On this basis it is a feasible proposition to anticipate the amount of load to be carried and to arrange to carry the load in the most economical, flexible and reliable manner.

Let us say that we anticipate that the hourly station load for a given day will be as shown by the boiler-room operating log. By reference to the curves, Figs. 1 and 2, we are able to calculate how we can best carry this load for maximum economy and reliability, which data are also posted to the boiler-room operating log. By posting these data on a large blackboard in the boiler room, we have conveyed to the operators and the firemen the necessary information to check up the performance of the units operating under their care and to obtain maximum economy of operation.

It is a well-known fact that the underfeed stoker displaces a given quantity of coal per stroke of the ram, the weight of which will not vary over very wide limits with coal obtainable at any one plant. On the basis of these data the number of turns of the stoker crank to supply the coal to the furnace to develop a given boiler rating is easily determined. As a definite relation exists between the quantity of coal burned and the

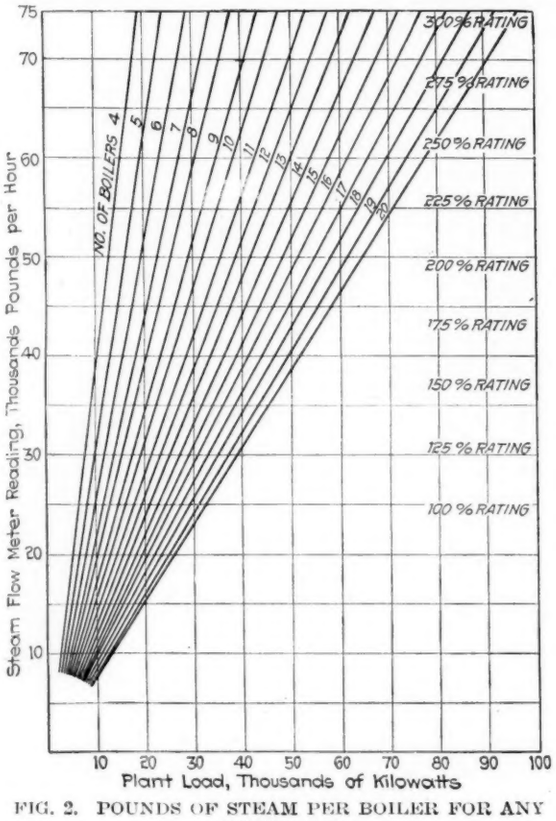


FIG. 2. POUNDS OF STEAM PER BOILER FOR ANY PLANT LOAD

quantity and pressure of air required to burn it, and as the quantity of air delivered is directly related to the pressure for any given condition, a definite relation in consequence exists between the quantity of coal burned and the air pressure. This relation can in turn be used to guide the firemen as to the amount of coal supplied or revolutions of the stoker crankshaft or strokes of the plunger in order to maintain the proper fuel-bed relations for any given set of conditions.

Supplying the firemen with and applying these data it is possible to maintain high efficiency of operation and eliminate the factor of guess.

EDITORIALS

Purchasing Summer Current

ON OTHER pages of this issue is a brief account of how an enormous saving was made in the power plant of a Chicago office building. As estimated, the gain is greater than the total operating expense should have been and is a good illustration of the latent possibilities in numerous plants where operation has degenerated into a routine grind with no initiative toward improving the equipment or the economy of existing apparatus. In the present case the impending fuel shortage called a halt on undue waste. Suggestions received from the Fuel Administration and the results achieved (almost too good to be true, as expressed by the management) are given in the story previously cited.

Mechanically, the plant was in deplorable condition, so that improvement in the equipment was easy. A big factor in the saving, however, was the purchase of summer current, obtained at a low rate in a favorable contract containing provision for off-peak service only during the four colder months. In November, December and January, except on holidays, the peak period lasts from four to eight-thirty in the evening, and in February the starting time is delayed one-half hour. During any other period of the year the service may be used twenty-four hours in the day if desired. In mild winter weather purchased service might be used to advantage during the night or even during the day to care for that part of the electrical load in excess of heating requirements. The big advantage, however, is during the six warmer months of the year in those plants where there is comparatively little use for exhaust steam. A minimum charge per kilowatt of demand per year is called for in the contract, but the figure is low enough so that the requirement can be met by six months' operation on full Edison service.

A spirit of coöperation, rather than the old attitude of "all or none," is evident. As *Power* has always contended, each type of plant has its field and a legitimate service to perform. The noncondensing plant that has full use for its exhaust steam is more economical than the most efficient condensing plant. With the exhaust steam wasted to atmosphere during the warmer months, however, as in the average office building, the isolated plant is at a decided disadvantage, so that it is profitable to purchase current if it can be obtained at a proper rate.

In Chicago and certain other cities, under the contract previously mentioned, attractive rates are available. The desire to fill in the summer valley and to utilize generating equipment, mains, etc., already installed to care for the heavier winter load are the reasons advanced. Increasing the bulk production through the period of lighter load means some addition to the profits of the central station and a considerable saving to the small noncondensing plant that cannot utilize its exhaust steam and where the electrical load is the principal factor. The advantages, then, are mutual, and a feature that has not been overlooked in war times and that must be given more attention in the future is the saving in coal that may be effected. As the supply is not unlimited, the welfare of future generations demands conservation.

In the average noncondensing plant, even of modern design, burning Western coal and carrying a variable load with the usual long standby periods, the use of seven, eight or even a greater number of pounds of fuel per kilowatt-hour is not uncommon. This may be compared to the three pounds or less of coal required by the best central stations to produce the same unit of electrical energy.

Figures taken from the published rate sheet of the company for off-peak direct-current service will serve to illustrate the monetary saving. In a plant where the maximum demand is 300 kilowatts and the load factor is 33⅓ per cent., which is equivalent to eight hours' use of the maximum, the total net rate, including both the demand and energy charges, is 1.56 cents per kilowatt-hour. For maximum demands of 200, 150 and 100 kilowatts at the same load factor, the total net rates are 1.66, 1.76 and 1.92 cents, respectively. For alternating current the rates are lower. Coal at six dollars a ton costs three-tenths of a cent per pound, so that with the quantity of coal known, it is easy to figure the charge per unit. If it is seven pounds, it would mean that coal alone would cost 2.1 cents per kilowatt-hour. This figure is greater than the rates quoted and of course does not include the extra labor and supplies that would be required to operate the generating plant.

An alternative method of operation would be for the Manhattan Building plant to run under a load great enough to supply all the exhaust steam needed and to deliver all excess electrical energy back into the Edison mains. Of course such an arrangement would depend on the willingness of the Edison company to allow a fair rate for all current thus delivered.

Maintaining an organization is a feature to be considered, but the alternate six-month plan would reduce this difficulty to a minimum. A marked advantage would be outside service always available in case of breakdown. Every plant, of course, has certain services to maintain, the equipment installed is a factor and the investment must be considered. For each it is an individual problem requiring careful study. With the present high prices of coal and no immediate prospects for cheaper fuel, the purchase of summer current should be considered. The plan is sure to save coal, and with rates as low as those quoted there should be a reduction in operating expense.

Right now is the time to investigate and, if conditions warrant a change, to prepare for service next summer.

The Pot Called the Kettle Black

JOSEPH HARRINGTON, speaking in one of the discussions at the recent annual meeting of the American Society of Mechanical Engineers, told of the air of superiority and sacrosanctitude affected by some of the larger plants when the matter of questionnaires was first broached.

"Oh, of course," they said condescendingly, "that is an excellent idea so long as you confine it to these little one-horse places where the whole operating force consists of a coal-heaver and a throttle-twister. But when you come to a big outfit like ours—well, you're only wasting our time and your own. If you insist on our filling out all those blanks you'll only make your plan ridiculous. We know all about these various precautions. We've been observing them for years. In fact, we invented the most of them ourselves."

Despite all these fair words—or others of similar import—the fuel-administration officials remained unwheedled. Braving the possibility of ridicule, they insisted that all power plants—regardless of size, color or previous condition of pulchritude—fill out the questionnaires; and when the results were analyzed, there was heard no loud guffaw of ridicule, no horse-laugh of derision. The plants that had been waiting the signal to break out into cacophonous scoffing suddenly found that they had urgent business on hand in the way of patching broken baffles, stopping up air leaks in boiler settings, cleaning soot from tubes and so on.

In the language of the fuel administrator for Illinois, "It was discovered that the small plant had no monopoly of inefficiency."

Of course it hadn't. A plain brick boiler setting is a sieve for air, whether it stands in the Podunk Corners grist mill or decorates the boiler room of the Metropolis Light and Power Company. Soot collects just as readily in a boiler at Manhattanville as it does in one at Cooper's Crossroads, and the fireman at either place is prone to pass up the job of blowing the tubes if he thinks he can get away with it successfully.

Don't Let Up on Buying War Savings Stamps

EVERY time a citizen of this country buys a Liberty Bond or a War Savings Stamp, he adds to the strength of the allied armies, because these are the agencies through which the Government is able to exchange its credit for the money of its citizens. The Liberty Bond has the prestige of a larger value, but the War Savings Stamp possesses the advantage of a wider distribution. Where one person may buy a bond, five will buy stamps.

Millions of workers in the United States are getting wages such as were not dreamed of in the years before the war. Now that the glorious end has arrived, much of the labor at present spent on war work will be unnecessary and the scale of wages fostered by the urgent demand must decline. If you have not already acquired the habit of buying War Saving Stamps it is not too late to begin, as their sale will be continued during the coming year.

'Ware the Second-Hand Boiler!

DURING the war, when industries had to be kept going and it was impossible to get new boilers or material from which to make them, many second-hand boilers that would otherwise have been discarded were put into service. With the passing of the exigency these boilers should not be forgotten, and should be recalled as they can be spared, and in such a way that they will not get into the hands of those who may use them with less circumspection.

The situation has been met in England by an order issued by the Minister of Munitions, to the effect that no person shall, except under and in accordance with the terms of a permit issued under the authority of the Ministry of Munitions, purchase, sell or otherwise deal in any second-hand steam-pressure boiler of any type, not being a boiler for use in any locomotive, motor car or vehicle, or on a ship or other vessels.

In some of the reports concerning the discovery of a new and successful fuel for internal-combustion engines to take the place of gasoline, it is asserted that this new "Liberty fuel" requires less air for combustion and at the same time gives more power or heat. It is not likely that engineers will accept this statement as correct, unless there is oxygen in some form incorporated in the fuel, which seems unlikely in view of the fact that it is air, or the oxygen in the air, that supports combustion and that carbon, hydrogen and oxygen are mutually dependent on one another. Combustion within the cylinder of such an engine is governed by the same laws as in an ordinary furnace. The statement is probably due to overenthusiasm.

The discussion going on in the correspondence pages in regard to the best relative position of blowoff valves and cocks should become more general. Almost every engineer has his opinion on the subject, based on experience and observation, and by an interchange of views the best may become apparent. The question is not which is better to use, a valve or a plug cock, nor what make or design of either is to be preferred, but which should be placed nearest to the boiler and why?

The timeliness of the subjects of the papers presented and earnestly discussed at the recent annual meeting of the American Society of Mechanical Engineers confutes the subtle accusation that engineers do not keep sufficiently up to date. The worst that can be truthfully said is that they do not foist themselves and their profession on the public; in other words, they don't make noise enough about their work.

The work of the Fuel Administration should be preserved and continued. No other institution has such possibilities of good for the power plant and the engineer. If you have any influence with your Congressman tell him so.

According to the Bureau of Mines, fuel oil sufficient to operate the railroads of the United States for one month is wasted each year by users. Time for someone to get busy.

CORRESPONDENCE

In these and other columns "Power" wants to tell how you have decreased the fuel consumption in your plant. Since the fuel shortage, engineers have been thinking hard about conserving fuel. Thousands have made changes in equipment, in operating methods, and in modifications to boiler settings, etc., all of which have, in many plants, greatly cut fuel consumption. You owe it to the country to tell your fellow-engineers how you have saved coal. "Power" will pay for good articles that will help the other fellow save coal as you have saved it. Engineers must save at least 35 million tons this year. Let's have your story.

Discussion on Motor-Starting Resistances

I have read with a great deal of interest the article by B. W. Jones in the Nov. 19 issue of *Power*. I should be very much interested in a further discussion by Mr. Jones on the following points:

A justification for the tables and illustrations of the action in the case of two or three motors—typical cases.

The reasons for specifying so many more resistance points with manual control than with magnetic control.

The tables given apply to shunt motors, 50 per cent. compound motors and series motors. How should this information be applied to standard compound motors with 20 per cent. and 40 per cent. compounding?

Some discussion of the comparative resistance for use with series motors with series lock-out control as contrasted with speed-control service would be valuable. I believe the tables given refer to series lock-out acceleration.

Mr. Jones has given the current values at which resistance sections should be cut out with shunt motors.

Are similar data referring to series motors available?

Mention has been made only of the proper ohmic value of accelerator resistors. Information as to desirable current capacities would be valuable.

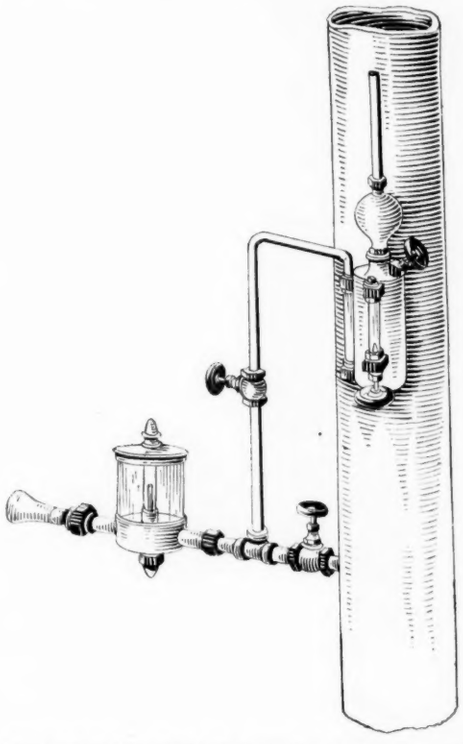
The writer, for one, would be interested in remarks by Mr. Jones as to the proper resistance for series motors subjected to plugging service. Also in a discussion on resistors for dynamic braking, and information as to resistors for dynamic lowering, as in crane service and armature shunts for slow-down work.

Indiana Harbor, Ind. GORDON FOX.

Handy Lubricator Kinks

Mr. Richey's letter in the issue of Oct. 1, page 502, describing a handy way of filling lubricators, induced me to submit the following, which I think is also good: Almost all engines and steam pumps have, and all should have, a hand oil pump to be used in case of emergency. By inserting a tee and valve between the pump and steam pipe and connecting a pipe from the tee to the top of the lubricator reservoir, as shown in the illustration, the pump can be used to fill the lubricator. Or by closing the valve to the lubricator and opening the one to the steam pipe, oil can be pumped directly into the steam pipe whenever desired.

To fill the lubricator it is not necessary to drain the reservoir or disturb the valves unless it is found that the impulses from the pump soil the feed glass, in which case simply check or entirely stop the feed while filling. When oil is pumped into the top of the reservoir, the water is forced from the bottom up through the condensing chamber and pipe into the steam pipe and passes out through the engine. By this means there is no necessity for a drip pan, waste or wrench, as the lubricator remains closed and clean and not a drop of oil is wasted. If the lubricator



LUBRICATOR FILLED WITH A HAND PUMP

should run dry and hot, as they sometimes do, close the feed valve to keep the feed glass clean and pump in the oil. This will force any water that may be left in the lubricator out of the reservoir and into the condensing chamber where it is needed, thus putting the lubricator in condition to begin feeding without loss of time, spattering of oil or burnt fingers.

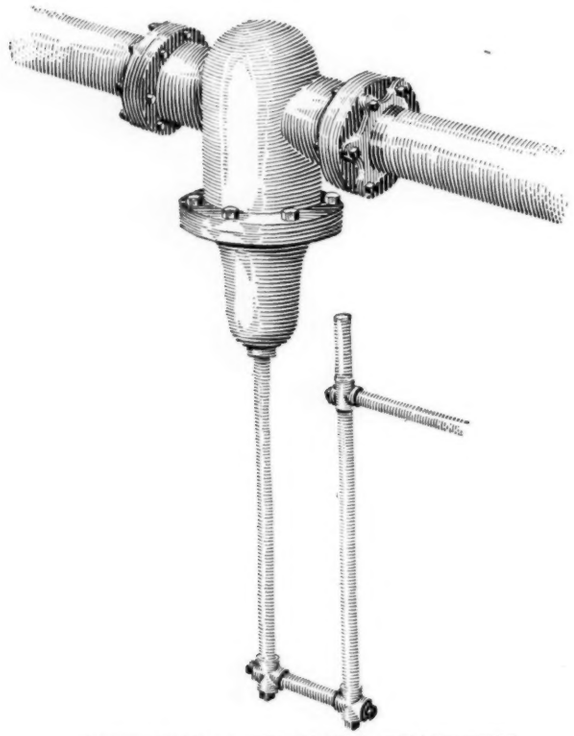
I once made use of a combined hydrostatic and mechanically operated lubricator arrangement, with considerable satisfaction. I secured an inexpensive force-feed lubricator pump, without a sight-feed glass, and connected its discharge pipe to the top connection of the oil-reservoir glass of the hydrostatic lubricator in the same way as shown for the hand pump. By closing the steam valve in the condensing pipe and

opening the feed valve wide, the oil pump fed through the sight-feed glass where it could be observed much better than in most force-feed lubricators. If the pump should fail, the lubricator can be turned on in a moment by opening the steam valve on the condensing pipe and regulating the feed.

Wadsworth, Ohio. B. E. ECKARD.

Draining an Oil Extractor

We had an oil extractor on a pump exhaust line that gave good results, but trouble was experienced in draining it because the trap became gummed with the thick oil and was sluggish in operation. We finally hit on the plan of using a U-pipe or seal, as shown in the illustration, to accomplish the work, allowing a



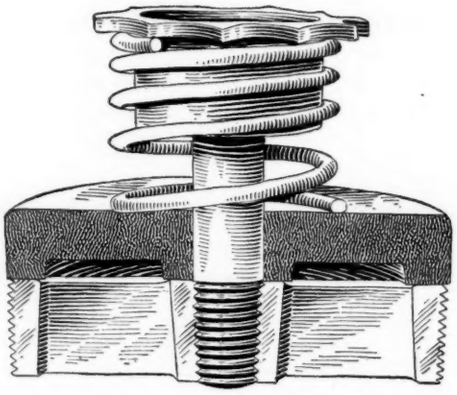
DEEP SEAL IN SEPARATOR DRAIN LINE

depth in the seal of about two feet for each pound of pressure carried. This arrangement drains off the waste continually without loss of steam and without trouble from stoppage. Plugged crosses were used so that the pipe could be cleaned out if necessary.

Philadelphia, Penn. M. A. SALLER.

Improvement in Pump Valves

An engineer who had had considerable trouble with the hard-rubber valves on a large pump handling hot water, tried the following remedy with good results. A short time after hard-rubber composition valves are put in use, the parts over the openings between the ribs of the seats become raised slightly, and as the valve does not always seat in exactly the same position, the raised part may prevent tight closing. At first, when this occurred, he would remove and reface the valves, which was quite a job. One day he took a set of old valves and turned out the central portion, forming a circular groove as shown in the illustration, and put them in the pump as an experiment. After two years' use the valves are still doing good work. They have not warped and have required no



RUBBER PUMP VALVE IMPROVED BY REDUCING FACE

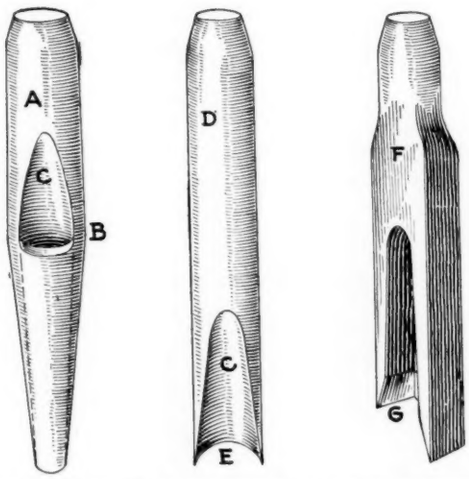
refacing, and even when they do require refacing it will be much less labor than formerly because the surface to be faced is greatly reduced.

Portsmouth, Ont., Canada. JAMES E. NOBLE.

Tools from Broken Belt Punches

A belt punch is an almost indispensable tool around a steam plant, and its frequent and hard usage often results in its being broken and thrown away. With a little remodeling a broken punch can be converted into a useful tool for cutting either round or square holes in gasket material or sheet metal.

Ordinarily, the punches are of tubular construction for a part of their length, as represented by *A*. When one of these breaks off at *B*, by means of a round file and



TOOLS MADE FROM BROKEN BELT PUNCH

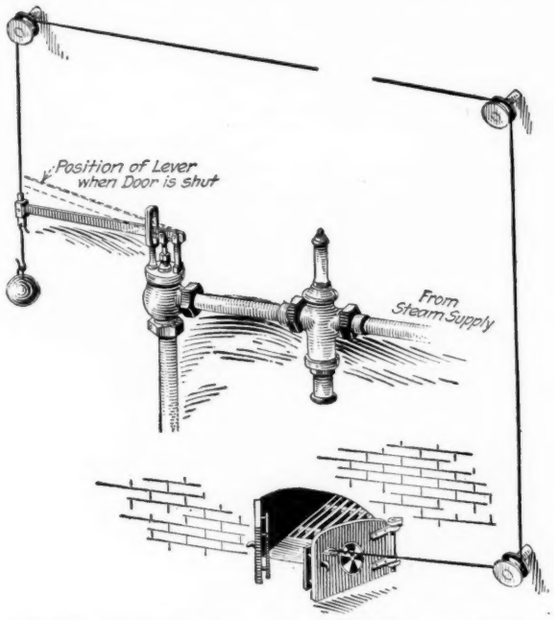
a vise the upper part can be easily hollowed out a little more, as at *C*, and rounded off on the back until a semicircular cutting edge is obtained, as represented at *D* and the edge *E*. Also, by means of a little heating and forging the broken part can be shaped like *F*, with an edge as shown at *G*, making a half-square cutting edge.

T. M. STERLING.

Canton, Ohio.

Automatic Control for Forced Draft

We use a turbo-blower controlled by a regulator to govern the speed of the blower as the steam rises and falls. In burning fine slack coal or dust there is a



BLAST SHUT OFF WHEN FIRE-DOOR IS OPENED

considerable backfire when the furnace doors are opened for firing, and sometimes the firemen are burned by the rush of flame when the coal is especially dry. To avoid this trouble we have arranged a balanced valve to be operated by the act of opening and closing the furnace door—cutting down the speed of the blower when the door is opened. The operation is shown in the illustration, and the details can be arranged to suit a given set of conditions. J. T. SHARP, JR.

Canton, Miss.

Internal Feed Pipe Scaled Up

Reading Mr. McLaren's letter on page 787 in the issue of Nov. 26, on placing a pan under the end of the feed-water pipe inside of a boiler, reminded me of an experience I had a number of years ago. It was in a planing mill, and my job was to feed an old 40-hp. boiler all the shavings it could eat and to keep the engine well greased; in fact, I was chief engineer, fireman and general roustabout.

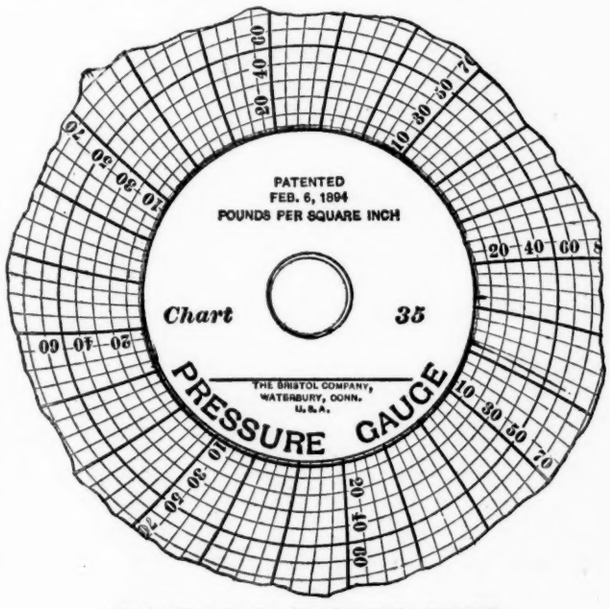
Things ran along for two weeks or more, when one morning I noticed the water level in the boiler was going down gradually. We had about 100 lb. city-water pressure and the steam pressure carried was only 80 lb., so we did not need a pump or injector to feed the boiler. I opened the feed valve wide and looked for the boss and told him about it, and we shut down. I checked the water pressure and found it all right. We let the boiler cool down, and the next morning I was on the job about 6 o'clock trying to find the trouble. I took out the manhead, which was on top of the boiler, and found a mound of solid scale from the tubes to the top of the boiler shell. The feed water entered the boiler at the top about halfway between the manhole and the back head. Getting into the boiler, I knocked away some of the scale with a cold chisel and hammer and found five pans on top of the tubes under the feed-water pipe. The bottom pan was about 8 x 12 in., the rest were smaller; each pan had four legs, or supports, under it which held them about 1½ in. apart. The water entering the boiler on top ran down over these pans about the same way as it does in some open feed-water heaters. The owner told me that his father had a patent on that "lime catcher" as he called it.

After taking out the pans, I found that the feed-water pipe was stopped up with scale. I cleaned the pans, got out what scale I could knock loose, replaced the feed-water pipe with a new one and closed up the boiler. After that I cleaned the boiler every six weeks and always found scale and mud in the pans. About everything in this whole plant was either made or designed by the father of the owner, who had spent his whole life experimenting. The old boiler was equipped with what he called side heaters consisting of ten or twelve 2-in. tubes about 30 in. long, with a connecting header, on each side of the firebox. The bottom headers were connected to a big cast-iron mud drum back of the bridge-wall, and the top headers were connected with a special fitting to the front head about 6 in. above the tubes. The feed-water heater was of the closed type, home-made, as was about two-thirds of the engine. The engine had a ball-shaped crankpin and a home-made cylinder with a piston valve. JOSEPH GERBER.

Dansville, N. Y.

Recording Gage on Pop Valve

In order to prevent the loss from needless blowing of the pop valves on our boilers, we connected a recording pressure gage to the discharge of the pop valve.

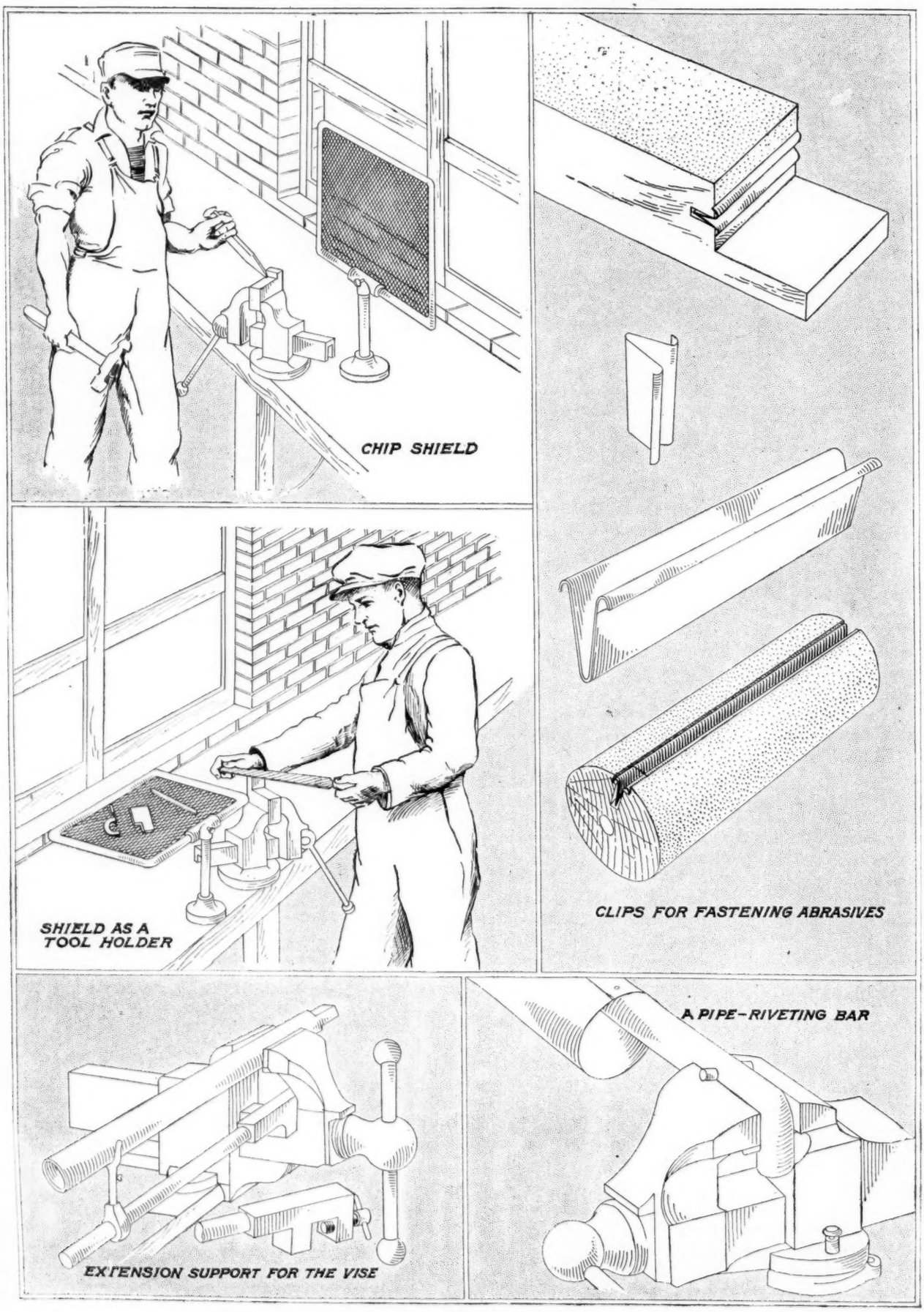


RECORD SHOWS WHEN POP BLOWS

The chart in the illustration shows that the valve opened only once in twenty-four hours. When coal is $5 per ton a 3½-in. pop valve can waste a lot in needless "pops." J. T. SHARP, JR.

Canton, Miss.

Some Kinks That Are Worth Trying

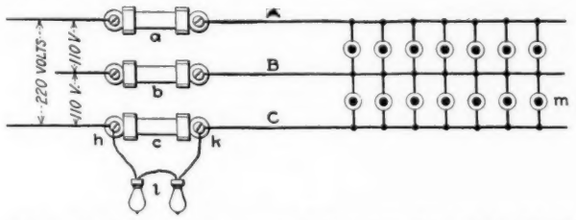


INQUIRIES OF GENERAL INTEREST

Motor Should Be Run at Rated Speed—When the field current of a motor is reduced its speed increases. Since it takes less current at the higher speed, why should it not be economical to run the motor at the greater speed, maintaining normal speed at the load through a greater reduction ratio by using a smaller driving pulley or a larger receiver? B. C. M.

While it is true that a motor will operate at an increased speed when the field current is reduced, it would be found that the armature current is thereby increased and that this increase more than counterbalances the decrease in field current.

Why Test Lamps Lighted—With wiring as shown in the sketch the lamps across *BC* went out, indicating that either or both of fuses *b* and *c* had blown. While using test lamps *l* to locate the fuse, it was noticed that when held across the terminals of *c*, which was the fuse blown, they lit up. Why should they do so? A. K. V.



When the lamps *l* are connected across the points *hk* they furnish a path for the current that would ordinarily pass through the fuse *c*. The value of the current will of course be restricted to that which can flow through *l* at the voltage impressed. This voltage will be very nearly 110 volts if a considerable number of lamps *m* are turned on. The fewer the lamps the greater will be the voltage across them and the smaller that across *l*. For example, if only one lamp *m* were turned on, we would have it connected in series with the two at *l* and the voltage drop across the former would be $\frac{1}{3} \times 110 = 37$ volts, and across the latter, $\frac{2}{3} \times 110 = 73$ volts, provided all the lamps were of the same size. If none of the lamps *m* was turned on, lamps *l* would not light up.

Small Power Obtained from Low Fall—How much power can be obtained with an undershot waterwheel operated with 18-in. head of water of a stream 25 ft. wide and flowing with an average depth of 18 in. and average velocity of 3 miles per hour? F. N. B.

The flow of the stream would be $\frac{5280 \times 3 \times 25 \times 1.5}{60} = 9900$ cu.ft. per min., and with 18-in., or 1.5-ft., actual working head, the horsepower of the water would be $9900 \times 62.3 \times 1.5 \div 33{,}000 = 28$ hp. The efficiency of a good form of undershot waterwheel would be about 70 per cent., and the power obtained would be about 70 per cent. of 28 = 19.6, or about 20 horsepower.

Utilizing Exhaust for Heating—In using large quantities of steam at 5 to 10 lb. gage pressure for boiling and drying work, would it be more economical to use exhaust steam and run a condensing engine noncondensing with the necessary back pressure, or to continue to run the engine condensing and supply the heating with live steam through a reducing valve? S. C.

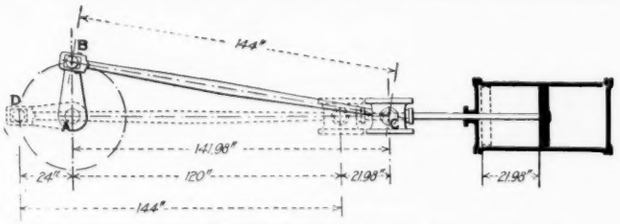
When operating the engine with 5 to 10 lb. back pressure, and there is use for all of the exhaust, it would be practicable to depend on the exhaust to furnish about 80 per cent. as much heat as would be derivable from the same quantity of live steam as that supplied to the engine. For instance, if it is allowed that 15 per cent. more of steam would have to be supplied to the engine, the exhaust could replace live steam now used for heating to the extent of 0.80 of 1.15 or 92 per cent. as much live steam as used by the engine when operated condensing, and the gain would amount to a saving of 0.92 — 0.15 or 77 per cent. as much live steam as now used for operating the engine condensing. The cost of substituting exhaust for any quantity of live steam up to 80 per cent. of the whole amount required for operating the engine run condensing will be the additional amount of steam that must be supplied to the engine for operating noncondensing. It is therefore impractical to replace any smaller quantity of live steam now used for heating than the additional amount thus required from increasing the back pressure, but this condition can frequently be met by using the exhaust of only one end of the engine cylinder.

Trouble with Cylinder Lubricator—A cylinder lubricator for vacuum pumps will not operate with the condensate pipe connected to the steam line, and it is found necessary to connect with a high-pressure water line. As this water line is sometimes without pressure, how can sufficient pressure be obtained for the lubricator? A. B.

The fact that the lubricator operates by connection with a high-pressure water line indicates that it would operate with the same condition of passages and same oil, if the condensate pipe were connected to the steam line at a point high enough above the lubricator. With ordinary sizes of passages and oil of usual viscosity, connection with the steam line at a point three to four feet above the level of the lubricator outlet should work satisfactorily and making the connection at still greater height will insure greater certainty of operation.

Position of Piston with Crank on Quarter—If the stroke of an engine is 48 in. and the connecting-rod is 12 ft. long, how far has the piston traveled when the crank is on a quarter? P. D.

As the length of crank is 24 in. and length of connecting-rod 144 in., then when the piston is in the crosshead end of the cylinder and the crank is on the center *D* shown in



POSITION OF PISTON WITH CRANK ON QUARTER

the sketch, the distance of center of the shaft from the center of the crosshead pin would be 144 — 24 = 120 in. When the crank is on a quarter as at *B*, its center line *AB* is at right angles with the cylinder center line *AC* and the center line of the connecting-rod *BC* is the hypotenuse of a right-angle triangle *ABC*, wherein

$$AC = \sqrt{BC^2 - AB^2}, \text{ or } AC = \sqrt{(144)^2 - (24)^2} = 141.98 \text{ in.}$$

Hence for movement of the crank from the dead-center *D* to the quarter position *B*, the center of the crosshead pin would be 141.98 — 120 = 21.98 in. farther from the center of the shaft than when the crank is at *D*, and the piston would be that distance from the crank end of its stroke.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Conservation of Heat Losses from Pipes and Boilers*

By GLEN D. BAGLEY

This paper presents the results of a series of experiments on magnesia coverings. The methods of measurement of the losses from bare and covered pipes are described. The effect of the various factors of steam temperature, cost of coal, and size of pipe on the economic side of the problem is worked out and tables are given showing the proper thickness of covering to use under all conditions.

THE purpose of this paper is to present a more complete and detailed method of solving the problems involved in the calculation of the heat losses from bare and covered pipes and the economic problems encountered in the practical application of coverings. The

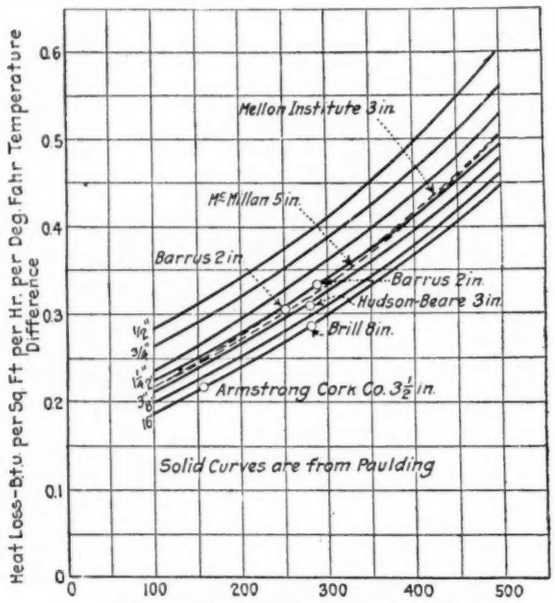


FIG. 1. HEAT LOSS FROM BARE PIPE

factors in the economic calculations are the cost of the heat, the cost of the covering, the size of the pipe, the temperature of the pipe and the temperature of the atmosphere. The data contained in the paper are a part of the results obtained in an investigation conducted for the Magnesia Association of America by the Mellon Institute of Industrial Research.

It is generally recognized that the losses from bare pipes and boilers are considerable, but their real magnitude is little appreciated. The fact that the loss from 100 sq.ft. of exposed surface at 100 lb. per sq.in. steam pressure amounts to over 300 tons of coal annually is sufficient justification for serious consideration of the subject.

In a study of the conservation of losses the first important fact to be considered is the actual value of the losses from bare surfaces. It is often considered that the loss from any bare surface is 3 B.t.u. per sq.ft. per hour per degree F. temperature difference between the surface and the surrounding air. While this value is correct for some special cases, it is by no means generally so. Most investigators have confined their measurements to one size of pipe at one temperature difference. Both the size of pipe and the temperature difference have an important effect on the value of this constant. Paulding, in his book on "Steam in Covered and Bare Pipes," has worked out the theory of heat losses from bare pipes from the researches of the French physicist, Péclet. The curves of Fig. 1 show the application of this theory to horizontal pipes. The solid curves indicate Paulding's values, while the dotted curves and the points give the results of various experimental tests.

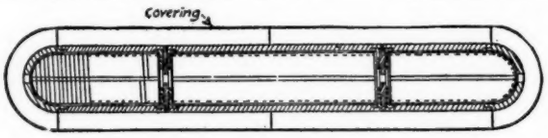


FIG. 2. CROSS-SECTION OF HEATER WITH COVERING APPLIED

The next important point in a consideration of the conservation of heat losses is the value of the loss after the pipes are insulated. Fig. 2 shows a cross-section of the heater with the covering applied. The case of the heater consisted of three pieces of 3-in. pipe, the middle section being 3 ft. long and each end section 1½ ft. long. The sections were connected by heat-insulating disks of asbestos board, and each end section was provided with a hemispherical cap of cast iron. Inside of each section was an electric heater made by winding resistance wire on a frame of asbestos boards. The wires were finely spaced and close to the inner surface of the pipe.

Tests were made on five different makes of magnesia, in 1-in., 2-in. and 3-in. thicknesses. The results of these tests are shown in Fig. 3. These curves are all corrected for slight variations in thickness so that they are true curves for the thickness given. Fig. 4 gives a comparison of the losses from a bare pipe with the losses through coverings 1 in., 2 in. and 3 in. thick. The contrast is very striking. The efficiency increases with the temperature, as the loss from bare pipe increases much more rapidly in proportion than the loss from covered pipe.

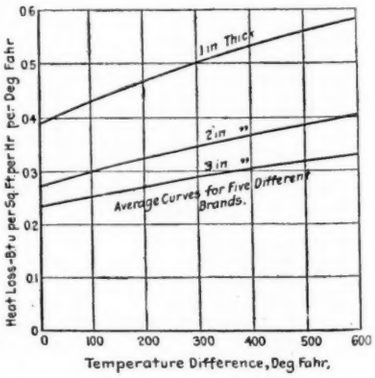


FIG. 3. HEAT LOSS THROUGH 85 PER CENT. MAGNESIA COVERINGS ON 3-IN. PIPE

Some tests have been made and others are now in progress to determine the effect of wind velocity on the losses from bare and covered pipes. The apparatus used to determine this effect consisted of a 35-in. Sturtevant blower driven by an 8-hp. direct-current motor which furnished a blast of air for a wind tunnel. The apparatus used for testing pipe coverings was arranged inside of the tunnel so that the axis of the pipe coincided with the axis of the tunnel. This caused the air to travel parallel to the axis of the pipe and gave a condition similar to that encountered in locomotive practice.

The first test was made with a 3-in. thick magnesia covering on the test pipe, a temperature difference of 460 deg. F. between the pipe and the wind, and a wind velocity of 30 miles per hour. Under this condition the loss was 0.430 B.t.u. per sq.ft. of pipe surface per degree F. tem-

*Abstract of paper presented at the annual meeting of the American Society of Mechanical Engineers, December 1918.

perature difference per hour. Under normal conditions of still air the loss was 0.302 B.t.u. This shows an increase of about 40 per cent. due to the wind velocity. From a theoretical consideration of the question, it can be shown that the maximum possible increase of loss due to wind will be reached when the temperature below the surface of the canvas covering on the magnesia is reduced to the temperature of the wind itself.

The last important point in considering pipe coverings is the permanency of their insulation value. Tests were made on several old magnesia coverings. Fig. 5 shows the conductivity of a 1-in.-thick covering which had been in service at the Armour Glue Works in Chicago for eight years. The conductivity was slightly lower than the average of the new 1-in. coverings tested, showing that no deterioration in service had taken place. Several sections were obtained which had been saturated with oil. Tests on these showed much lower insulation values than new coverings. The damage was permanent and shows that care should be used to protect coverings from oil while in service.

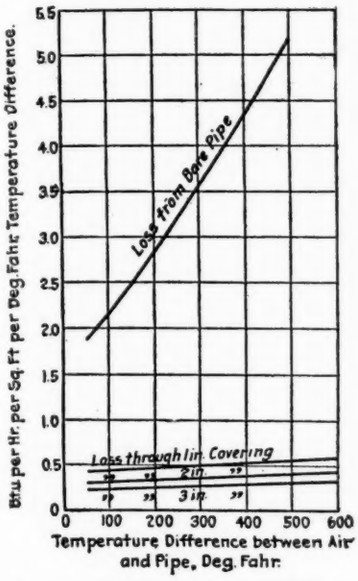

Btu per Hr. per Sq. Ft. per Deg. Fahr. Temperature Difference.
Loss from Bare Pipe
Loss through 1in. Covering
2in. "
3in. "
Temperature Difference between Air and Pipe, Deg. Fahr.

FIG. 4. HEAT LOSSES FROM 3-IN. PIPE WITH 85 PER CENT. MAGNESIA COVERING

After considering the technical and theoretical side of heat losses from bare and covered surfaces, the next point is the economic side of the problem. In most cases the result desired is the maximum net saving of money for any given condition. If the covering cost were nothing, the proper thickness would be limited only by the requirements of space available, as each increased thickness would result in some slight increased saving in heat. In a practical case where the covering has a finite cost, a point is soon reached where the increased cost of the covering would be greater than the additional saving in heat effected. The determining of this point is the thing in which the user of coverings is interested, as it is just at this point that the maximum net saving is accomplished.

In Fig. 6 a set of curves is given which shows how the list prices of coverings vary with the thickness. For flat surfaces the price is directly proportional to the thickness, starting at 30c. per sq.ft. for coverings 1 in. thick. The difficulty of manufacture of molded coverings for pipes results in an increased cost per square foot for a 1-in. thickness and the cost increases much more rapidly with the thickness than in the case of flat surfaces. More material is also required in molded coverings per square foot of pipe surface than in the same thickness in flat blocks on account of the curvature of the surface.

By means of the curves of Fig. 7 the cost per square foot of surface covered can be determined for any thickness desired. From this cost the

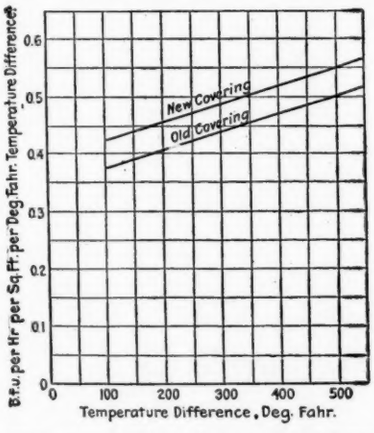


FIG. 5. COMPARISON BETWEEN OLD AND NEW COVERINGS

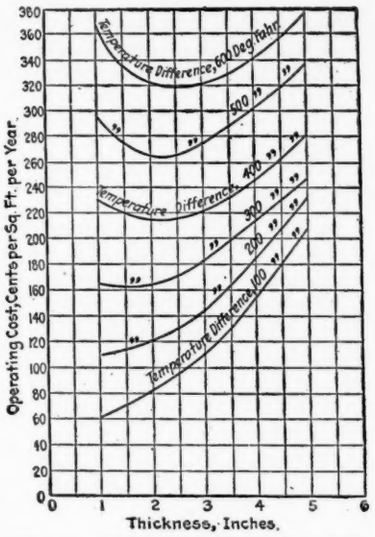


FIG. 6. CURVES FOR 3-IN. PIPE—STEAM COST, 80 CENTS PER 1,000,000 B.T.U.

annual fixed charges due to the covering can be calculated. After considerable investigation it was decided that 20 per cent. of the list price of the covering would be allowed as the cost of application, and 13 per cent. of the total cost as the annual charges (6 per cent. interest, 5 per cent. depreciation and 2 per cent. insurance and miscellaneous). This fixed charge was calculated for seven different sizes of pipes and five different thicknesses, based on list cost of covering.

The other cost to be charged to the operating expenses of the covering is the value of the heat losses through the different thicknesses of coverings. The previous work done on measuring the loss through 15 samples of magnesia furnished the necessary data for calculating the loss in heat units. After the heat loss was determined, it was necessary to convert the loss into dollars and cents. The assumptions used in making this conversion were that the cost of coal is 75 per cent. of the cost of steam, that 1 lb. of coal as burned will evaporate 7 lb. of water from and at 212 deg. F., and that each pound of steam contains 1000 B.t.u. above the feed-water temperature. The value of the heat losses was calculated for seven sizes of pipes, five temperature differences between pipe and air, and four different costs of heat, both on the basis of a known cost per million B.t.u. and on a cost per ton of coal and the average conditions of steam generation previously given. By making these calculations both ways, the results are applicable to plants where the steam costs are accurately known, as well as to those where accurate records are not kept.

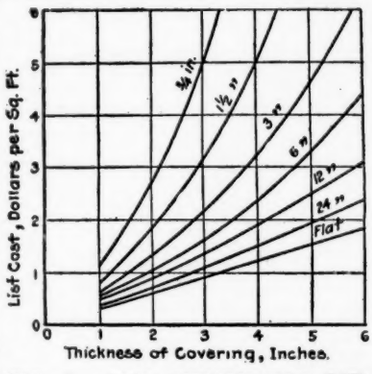


FIG. 7. COST CURVES FOR DIFFERENT-SIZED PIPES

By combining the fixed cost and the heat losses per square foot per year, the total operating expenses were obtained. Once these are obtained, it is simply a matter of picking that thickness which gives the minimum annual operating expense to obtain the proper covering to use. It is evident that the thickness which gives the minimum operating expense also gives the maximum net saving, as the loss from bare pipe is a constant under given conditions and the net saving is the difference between the operating expense and the loss from bare pipe.

The way in which the covering that gave the lowest operating expense was chosen was to plot curves of the type shown in Fig. 6 for the total operating expense for five different thicknesses. By selecting the thickness corresponding to the lowest point on each curve, the proper thickness of covering to use for the temperature difference corresponding to that curve was obtained. One set of these curves was plotted for each size of pipe at each of four different steam costs. From this set the thickness curves given in Fig. 8 were derived, and from the thickness curves Table I, showing the proper thickness in relation to coal cost per ton, was

obtained by making the assumption previously explained. From these curves and tables the proper thickness to use in order to obtain the maximum net saving under any condition may easily be determined.

In order that the results of the laboratory tests might be checked on a larger scale, several practical tests were made. The first and most important of these was a boiler test made at a mine in Bruceton, Penn. There were two boilers in the plant, of 80 and 60 hp., locomotive type. The exposed surface on these boilers was 675 sq.ft. The tests covered a period of 24 hours. Conditions of load, etc., were practically the same during both tests. During the first

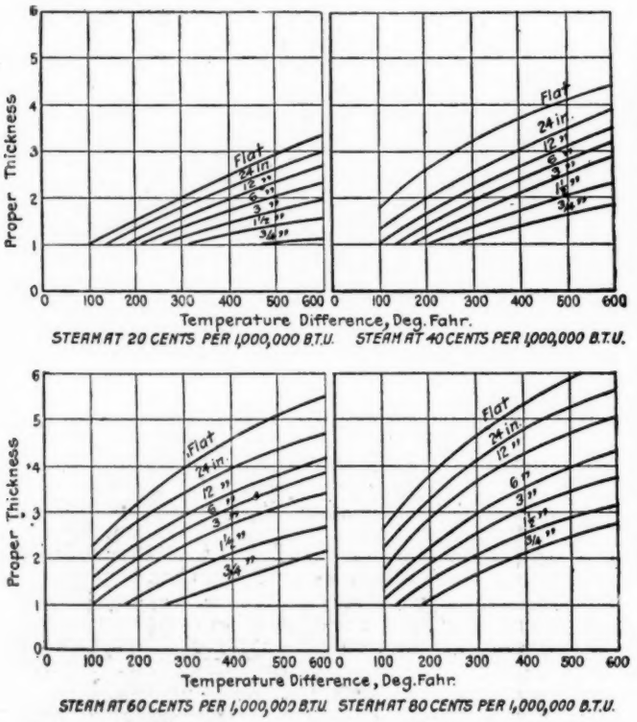


FIG. 8. THICKNESS OF 85 PER CENT. MAGNESIA FOR MAXIMUM NET SAVING

test, while the boilers were uncovered, 10,784 lb. of coal was burned to evaporate 58,000 lb. of water. In the second test, after the boilers had been covered with 2 in. of 85 per cent. magnesia blocks and plastic, 9296 lb. of coal was burned to evaporate 59,500 lb. of water. The evaporation rate during the first test was 6.35 lb. of water from and at 212 deg. F. per lb. of coal as fired, and during the second 7.55 lb.; 1500 lb. more water was evaporated with 1488 lb. less of coal burned. If calculated for an equal evaporation of water, the saving in coal would be 1700 lb. per day. The calculated saving based on the laboratory experiments was between 1400 and 1500 lb. per day. This saving amounts to 15 per cent. of the coal burned due to covering the boiler alone, as pipe lines were not included in the test.

TABLE I. THICKNESS OF 85 PER CENT. MAGNESIA FOR MAXIMUM NET SAVING

Thickness in Inches. S = Standard Thickness

Size Pipe, Inches	Hot Water, 175 Deg. F.	Steam, 5 Lb.	Steam, 100-200 Lb.	200 Lb. 150 Deg. F. Superheat	200 Lb. 300 Deg. F. Superheat
Coal at $2 per Ton					
¾	S	S	S	S	2
1½	S	S	S	S	2
3	S	S	S	1½	2
6	S	S	1½	2	2
12	S	1½	2	2	3
24	S	2	2	3	3
Flat	1½	2	3	3½	4
Coal at $4 per Ton					
¾	S	S	S	1½	2
1½	S	S	1½	2	2
3	S	S	1½	2	3
6	S	1½	2	3	3
12	S	2	2	3	4
24	S	2	3	4	4
Flat	2	2	3	4	4½
Coal at $6 per Ton					
¾	S	S	1½	2	2
1½	S	S	1½	2	3
3	S	1½	2	3	3
6	S	2	2	3	4
12	1½	2	3	4	4
24	2	3	3	4	5
Flat	2½	3	4	5	5½
Coal at $8 per Ton					
¾	S	1½	1½	2	3
1½	S	1½	2	3	3
3	1½	2	3	3	4
6	1½	2	3	4	4
12	2	3	3	4	5
24	2	3	4	5	6
Flat	2½	3½	4½	5½	6½

Motor Brushes for Use in Gritty Surroundings

In discussing R. B. Williamson's paper on "Electric Motors in the Cement Industry" at a recent meeting of the American Institute of Electrical Engineers, W. C. Kalb, of the National Carbon Co., said:

We do not find brushes so extensively used in the cement industry as in many others, owing to the predominance of alternating current. However, direct current is used to some extent and with considerable success. The application of brushes to this industry is very much the same as in any other, with perhaps the exception that self-lubricated brushes, so called, or those which are impregnated with the lubricating material, are not at all desirable in this industry. The presence of the abrasive material in the form of dust which can be accumulated by any sticky or lubricating material on the surface of the brush will cause unnecessary wear on commutators. Consequently, this type of brush should not be used in the cement industry or in any other where abrasive dust may be present.

As to undercutting the mica of commutators, in the presence of so much dust of this kind there is not the need for it that there is in other installations. The abrasion that occurs from the dust present would be sufficient to operate with flush mica, nonabrasive brushes. There will be conditions, however, where undercutting would be advisable unless abrasive brushes were used. In such cases the undercutting should not be deep; $\frac{1}{32}$ in. as a maximum will give successful operation, and it will not be deep enough to afford a pocket for the collection of dust so that it will cause any serious trouble if the machine is blown out with reasonable frequency.

Probably more brushes are used on the slip-ring types of motors in cement mills than are used altogether on direct-current motors, due to the predominance of the alternating-current motor. I would like to put in a word here urging the greater use of the carbon and graphite brushes as against the metal-graphite composition brush. This, of course, means cutting down the current density in the brush to come within the range of the carbon-graphite brush, but that is not a serious problem as there is always plenty of room for the commutator holders. An objection frequently offered by designing engineers to the use of the carbon brush on the slip-ring type of motor is that it increases the slippage. Again, for this industry, I do not think that would be a serious objection.

My reason for advocating the carbon brush is the tendency for all composition brushes, once abrasion has started, to of themselves continue that abrasion and break up the polish, the smooth surface of the brush face and the ring, resulting in considerable abrasion, short brush life and rapid ring wear. The carbon brush is not open to this objection.

In regard to the types of carbon brush to get the necessarily high carrying current, there are practically but two from which to choose—the all-graphite, which is made as a molded brush, from pure natural or artificial graphite, and the electro-graphite brush. I have a personal preference for the electro-graphite brush because of its greater hardness, greater mechanical strength and ability to stand up under severe mechanical conditions. It can be operated up to a current density of 60 amperes per square inch without difficulty, and where conditions are right a considerably higher current density is permissible, so it will take care of any condition to which a graphite brush can be applied.

The movement of coal eastward from the Logan and Kanawha producing districts in West Virginia is permitted in an order issued Dec. 17 by the United States Fuel Administration. It allows the movement of coal from Logan and Kanawha districts eastward in Virginia and West Virginia, on the main line of the Chesapeake & Ohio R.R., including tidewater and terminal points.

A "Natural Steam" Turbine Plant

IN MANY quarters of the globe there is a constant emission of steam or hot water from crevices in the ground. At Larderello, Italy, a small reciprocating engine was installed in 1897 and a larger one in 1905 to utilize this "natural" steam. The success of this plant encouraged enlargement and following is a description, taken from *Engineering* (London), of a new turbo-generator plant of 7500 kw. capacity.

In order to increase the output of steam, bore holes were

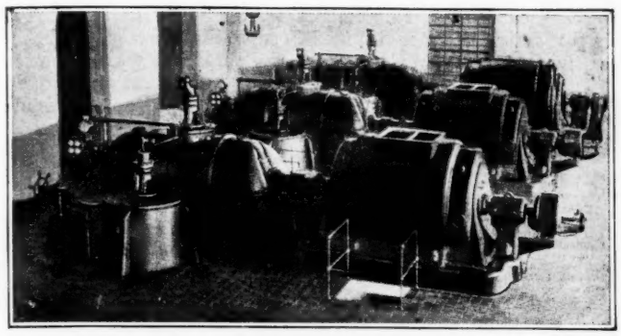


FIG. 1. INTERIOR VIEW OF PLANT, SHOWING THREE UNITS

sunk to supplement the natural flow. Some of these holes are 16 in. in diameter, and range in depth from 200 to 500 ft. The supply was thus largely augmented, and on closing in the top of some of the bore holes it was found that the steam pressure reached about 45 lb. gage and ample supply seemed to be assured, since it was found that the large increase that had been made in the number of bore holes sunk had in no way diminished the flow from previous existing vents. At the same time, as a bore hole, in the nature of things, is very adequately lagged, the temperature of this steam, as delivered, was much above the saturation temperature, being 356 deg. F., which corresponds to the temperature of saturated steam at a pressure of about 145 lb. absolute.

"Natural" Steam Used as Heating Agent Only

The condition of a supply of steam at low pressure and with a considerable superheat is one which is better adapted to the steam turbine than to the reciprocator, but on the other hand, the natural steam at Larderello is highly charged with CO_2 and other gases, which would make it difficult to secure the high vacuum, lacking which the advantages of the turbine are materially discounted. Hence, when the first turbine, a 250-kw. unit, was installed in 1912, it was decided to use the natural steam merely as a heating agent, and by its aid to evaporate pure steam at a lower pressure, to be used in the turbine. This plan proved quite satisfactory and was adhered to when installing the three 2500-kw. turbines, which were put into service in 1916. The evaporators used to supply the steam each consist of a vertical steel drum, the headers of which are tube plates, into which are expanded 300 aluminum tubes. These tubes are 7 meters long and 30 mm. in diameter. They were made of aluminum in order to resist the action of the sulphuric acid, which is found in the natural steam. This natural steam flows outside the tubes, and the water to be evaporated through them. The steam generated passes through a superheater before it enters the steam main. This superheater is heated by the natural steam on its way to the evaporator. The pressure at which the pure steam is generated is about 15-lb. gage, but the turbines are designed to give their rated load, with a gage pressure at the turbine of 2¾ lb. per square inch.

The new turbines run at 3000 r.p.m. and are coupled to generators supplying three-phase current at 4000 volts and 50 cycles per second. A view showing the three sets in place is reproduced in Fig. 1. The turbines are of the standard exhaust steam type, with reaction blading. Fig. 2 shows the rotor suspended over the lower half of the casing. The turbine is built on the double-flow principle, steam being admitted at mid-length, and flowing both ways to the exhaust ports at the end. There are thus two exhaust flanges which bolt on to corresponding branches on the condenser. The blading is divided into seven groups, of which five have brass blades, and the two remaining low-pressure groups have blades of 5 per cent. nickel steel.

With all exhaust-steam turbines, the design of the valves is a crucial question. The volume of steam to be passed is enormous, and a loss of pressure at the valves, which might be insignificant in the case of a high-pressure turbine, will materially reduce the output of an exhust-steam turbine.

In this instance the stop-valve and the governor valve are combined in the one casing. Both are of the double-beat type and are designed to pass 90,000 lb. of steam per hour at 2½-lb. gage pressure. The steam enters the valve casing from below, the admission pipe being 700 mm. in internal diameter. Provision is made for the expansion of this pipe without straining the valve, by employing a stuffing-box and gland. Each turbine has its condenser arranged immediately below it, and each condenser has a cooling surface of 11,300 sq.ft. The air pump is of the water-ejector type, and the condensate is handled by a centrifugal pump. The circulating water required is 9300 gal. per min., and as this is derived from cooling towers, its temperature is never really low. The efficient working of the turbines is thus

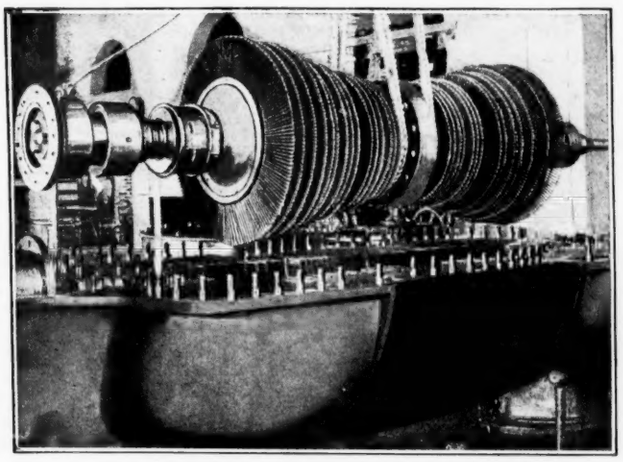


FIG. 2. ROTOR OF A 2500-KILOWATT TURBINE

bound up with the efficiency of the air extraction, and the makers state that with the ejector air pump fitted, the results have been highly satisfactory. Altogether the installation is an unusually interesting one.

A recent British report on power conditions says:

In the United States the amount of power used per worker is 56 per cent. more than in the United Kingdom. If we eliminate workers in trades where the use of power is limited, or even impossible, we shall probably find that in the United States the use of power, where it can used, is nearly double what it is here. On the other hand, not only are the standard rates of wages higher there, but living conditions are better. There is little doubt that in the United States the average purchasing power of the individual is above what it is in this country, and that this is largely due to the more extensive use of power, which increases the individual's earning capacity. The best cure for low wages is more motive power. Or, from the manufacturer's point of view, the only offset against the increasing cost of labor is the more extensive use of motive power. Thus, the solution of the workman's problem, and also that of his employer, is the same; namely, the greatest possible use of power. Hence, the growing importance of having available an adequate and cheap supply of power produced with the greatest economy of fuel.

Chicago A. S. M. E. View Shell Making

On Friday evening, Dec. 13, the Chicago Section of the American Society of Mechanical Engineers held its first dinner meeting of the season at the Hotel La Salle. Fitting with the day and date, the meeting was a great success. An innovation was the introduction of music throughout the meal, and for the first time those attending were grouped at table according to the division of engineering in which they were interested. An introductory film showed the 108th Engineers in camp in Texas. This was the first regiment of Illinois engineers in service. Their work in training was interesting, and the opportunity of seeing them at it was appreciated by their friends back in Chicago.

The speaker of the evening was D. L. Derron, of Winslow Brothers Co., Chicago. His topic was the manufacture of 155-mm. shells, and in this connection he gave the audience an opportunity to view one of the finest set of films ever produced. An aggregate of 8000 ft. of film traced the operations in turning daily 360 tons of steel into 1½ miles of shells at Winslow Brothers. The pictures were exceptionally clear and instructive, giving an excellent idea of the work and the surprising extent to which women were employed throughout the shop. They were originated to educate new employees and bring them to a high point of efficiency with the least delay.

Following, some interesting films were presented showing the manufacture of the enormous gun-boring planers with reinforced-concrete beds made by the Amalgamated Machinery Corporation. The speed with which these machines were assembled was little short of miraculous. The contribution of this company to the industrial branch of war work was highly praised by Mr. Derron.

Keep Up the Good Work of the Fuel Administration

The following resolutions were unanimously adopted at the International Power Economy Conference held at the City Club in Chicago on Dec. 10:

Whereas, It has been demonstrated and proved by competent engineers that one-quarter of the fuel mined in the United States is uselessly wasted by the consumer, said waste amounting to approximately 150,000,000 tons of coal per annum, representing in money value about $1,000,000,000; and

Whereas, Such waste is an economic crime, in that it increases the cost of fuel, which in its turn increases the already high cost of living through the increase in the cost of power production; and

Whereas, Our limited fuel resources should be conserved as far as possible for uses of posterity; and

Whereas, The National Fuel Administration has already performed a service of inestimable value to the country through its effective work in educating and otherwise assisting consumers of fuel; and

Whereas, This effective work of the National Fuel Administration is, in our estimation, a mere beginning of the good work that can be accomplished; and

Whereas, If some provision is not made to carry on the work so signally inaugurated by the National Fuel Administration, we believe that the good already done will soon be undone, and that fuel consumers will revert to their wasteful practices of the pre-war period; and

Whereas, The Bureau of Mines of the Department of the Interior is admirably equipped and otherwise qualified to take over and carry on the work of the National Fuel Administration; therefore,

Be It Resolved, That we, the International Power Economy Conference, call upon the Congress of the United States to enact such legislation as may be necessary to continue the work of fuel conservation so successfully begun by Dr. Garfield and his able associates.

And we recommend that the work of the National Fuel Administration be taken over and continued by the Bureau of Mines and that the said Bureau of Mines be given full authority by the appropriate legislation to enforce all the recommendations that it may see fit to make concerning the conservation of all fuels at their sources of production, in transportation and storage and in their final uses, whether for domestic purposes, for the production of light, heat and power, or for any other use whatsoever; and be it

Resolved, That a copy of these resolutions be sent to the following: The President of the United States; Members of the Congress of the United States; the National Fuel Administration; the Bureau of Mines; the National Press Associations; the trade press; and all engineering associations.

It was further resolved, unanimously, that the Executive Committee be authorized and instructed to communicate with the Director of the United States Bureau of Mines, advising him of this organization of power-plant equipment manufacturers, and offering the assistance and coöperation of the association in his work of fuel conservation.

After a morning and an afternoon session, devoted to technical discussions of the problems confronting power-plant operators, arrangements were made for a permanent organization. On motion of Joseph Harrington, in behalf of the Organization Committee, the chairman was authorized to appoint members of an executive committee to plan and supervise the organization of future conferences and also members of such other committees as may be found necessary to carry on the work outlined by or for such conferences.

Safety of Welded Headers on Water Tube Boilers

A recent issue of the *Schweizerische Bauzeitung*, in discussing the safety of welded headers on water-tube boilers, says:

Since 1912 eight serious header explosions have taken place in Germany due to the failure of the bottom plates of a header, in most cases the front one. Careful examination of the welded seams of the torn-out bottom plates proved not only that the welding had not been executed as thoroughly as had been supposed, but that it was impossible to obtain a perfect welding of the plates when the blunt edges were joined and treated in a coke fire.

The conclusion was also reached that the principal cause of the explosions could be found in insufficient protection of the headers against the flames, as was proved by the blue color of the bottom plates of nearly all exploded headers.

Since June, 1918, a law has become effective eliminating, as far as possible, all welded joints between the bottom and the tube plates of the headers, more in particular in the lower part of the front headers on the side most exposed to the flames.

Furthermore, the front header has to be located in such a way that any possible fault in the welding can be readily inspected. For boilers capable of evaporating over 5 lb. of steam per square foot of heating surface, the bottom back seam of the front header must be protected by masonry against continued exposure to high temperatures and particularly against immediate contact with the flames. This must be built-in in such a way that by looking into the combustion chamber any fault, such as broken-off or burnt masonry, can be observed. If this cannot be done in existing installations, some other satisfactory mechanical protection of these seams must be provided.

In the issues of Sept. 28 and Oct. 5, 1918, of the *Zeitschrift des Vereins Deutscher Ingenieure*, Hermann Bussmann, M. E., gives some further information concerning the considerations leading to the foregoing regulations. He shows with numerous illustrations how various German boiler designers have solved the problems of accessibility to the welded seam, the protection of the headers by masonry and the mechanical safeguards against failure of the bottom header plates.

Two-Thousand-Kilowatt Generator Explodes

On Dec. 10 the generator of a 2000-kw. turbine-driven unit of the reaction type in the St. Paul plant of the Northern States Power Co. exploded. The generator is a total wreck, but the turbine apparently is unharmed. The unit had been operating noncondensing, supplying exhaust steam to the district heating system owned by the company. The initial cause of the accident is not immediately apparent, but an investigation is now being conducted and further details should be available at an early date.

Dealing in America's Greatest Assets

The Professional Division of the United States Employment Service assists experienced technical men of the Army and Navy to find their places in work of reconstruction. Officers and men of the Army and Navy released from active service are being registered with the Division, and placed in touch with those employers who can best make use of their services.

The Professional Division deals only with those men who are well equipped by education and experience in their particular lines of work. The record of each man is carefully investigated before registration is permitted. Many university graduates in mechanical, electrical and civil engineering, and in chemistry, and other technical men with several years of practical experience, have already been registered. These men, who willingly severed their business relations more than a year ago to give their services to their country, are returning to civil life to find changed conditions. Although the industry of the country has great need of their services, neither men nor employers are able, without assistance, to discover each other immediately. To avoid delay in the readjustment processes, not only the labor of the country, but also the highly trained directors of industry, are being mobilized with the assistance of the Government. The aim is that each man shall fit in that part of our business organization where he can do his best work.

The task of dealing with thoroughly trained men wno in many instances can command high-salaried positions is requiring the assistance of those technical organizations which have heretofore placed university graduates and experienced men with employers. The Professional Division is seeking to coöperate with all such societies by referring properly qualified men to them, or by obtaining from them data on positions available.

The engineering field appears to present the largest problems of the Professional Division. Thus far, nearly one-half of all the applicants have been qualified for work in various forms of the engineering profession. The temporary lull in general construction work has in part closed one field which, it is believed, will be more available by the time the overseas forces begin a large-scale demobilization.

The Professional Division of the United States Employment Service has its New York office at No. 16 East 42nd St. Its registrations of experienced men are increasing. Employers seeking such men are asked to inform the Division of the precise nature of the positions which they have available. Only those men who are well qualified to fill such positions are referred to the employer.

Personals

J. J. McKee, formerly New York manager of the C. A. Dunham Co. of Marshalltown, Iowa, has resigned to take up work with the Machinery Utilities Co., of 501 Fifth Ave., New York City.

Engineering Affairs

The American Association for the Advancement of Science will hold its 71st meeting at Baltimore, Md., Dec. 23-28, with headquarters at Gilman Hall.

The Society of Automotive Engineers announces that the date of its annual winter meeting has been changed from Jan. 12-14 to Feb. 4-6 as a matter of convenience for members who desire to attend the automobile show which will be held at Madison Square Garden the first two weeks in February. This meeting will be the occasion of interesting technical sessions on the different automotives, and on fuel for internal-combustion engines.

Miscellaneous News

Valve in Boiler Room Explodes—The failure of a steam valve in the boiler room of the Eastern Avenue power station, Cincinnati, Ohio, at about 7:30 o'clock Thursday morning, Dec. 12, shut down almost the entire street-car service of the city for about half an hour. A fireman at work in the plant was seriously scalded about the upper part of his body, and was taken to a hospital. The cause of the failure has not yet been learned.

Business Items

The Yarnall-Waring Co. has acquired a three- acre tract at Mermaid Lane and Devon St., Chestnut Hill, Philadelphia, on which is a three-story stone mansion which is being converted into general offices, and a one-story modern machine shop has been erected in which manufacturing is now being carried on.

The Brown Hoisting Machinery Co. announces the following changes in its organization: Harvey H. Brown, chairman of the board of directors; Alexander C. Brown, president; Melvin Pattison, vice president, general manager and director; Robert G. Clapp and John F. Price, directors; Ewen C. Pierce, general manager of sales.

The Beckman & Linden Engineering Corp., of San Francisco, has purchased the Tesla coal mine near Livermore in Alameda County, and purposes to develop electrical energy at the mine. There is estimated to be 12,000 tons of lignite in this deposit, and it is the intention to use it in the form of pulverized fuel.

F. H. Williams, representative and European manager of the Keystone Lubricating Company de Philadelphie, Chemin de la Batterie 12, Marseille, le France, would be obliged to receive catalogs of lubricators (Stauffer type), steam packings or jointings, wire and manila ropes, rubber valves, engine and boiler-house fittings and mill-furnishing supplies, for which he has many inquiries abroad.

Pratt & Cady Co., Inc., announces that at a special meeting of its board of directors held on Dec. 2, the following changes in the official personnel of the company were made: Edwin L. King was elected treasurer to succeed the late Bishop White. Mr. King left the engineering department of The Travelers Insurance Co. upon his election as secretary and treasurer of the Pratt & Cady Co. in February, 1912. In the fall of that year he was appointed receiver of the company by the Superior Court and managed its affairs during the entire receivership period, selling the business, property and good will to Pratt & Cady Co., Inc., in March, 1914; O. Lamson Beach, who has served in various departments of the company and has been assistant sales manager for the last year and a half, has been appointed assistant secretary; Albert E. Oldroyd, who has been chief accountant since 1914, was elected assistant treasurer. The company recently purchased the property and business of I. B. Davis & Son, and will continue along with its own to manufacture the Davis line of goods.

New Construction

PROPOSED WORK

N. H., Portsmouth—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans improvements to power plant and distributing system here. Estimated cost, $188,000.

Conn., East Hartford (Hartford P. O.)—The East Hartford Fire District has been authorized to borrow $100,000 to purchase a pump and pipe line to increase the present water supply. C. H. Olmsted, Engr., preparing plans.

Conn., Hartford—Anderson Bros., 220 Windsor Ave., plan to build an 18 x 20 x 18 ft. engine house in connection with the 35 x 140 ft. monumental shop which will be constructed on Windsor Ave. An electric power system will be installed in same. Total estimated cost, $20,000. Berenson & Moses, 26 State St., Engr.

N. Y., Brooklyn—The Rushmore Paper Co., Meeker Ave. and Newton Creek, has had plans drawn for the construction of a 1-story, 42 x 55 ft. boiler house, on Cherry St. and Scott Ave. Estimated cost, $5000. E. J. Decker, 734 Vernon Ave., Long Island City, Arch.

N. Y., Buffalo—The city plans to install a steam heating system and electric elevators, in the first unit of the proposed 8-story municipal office building. Total estimated cost, $380,000. Essenwein & Johnson, Ellicott Sq., Engr.

N. Y., Long Island City—The Pennsylvania R. R., 7th Ave. and 32nd St., New York City, plans to build a 1-story boiler house at the Sunnyside Yards here. Elisha Lee, Broad St. Sta., Philadelphia, Penn., Gen. Mgr.

N. Y., Niagara Falls—T. Kenard Thomson, M. D., 50 Church St., New York City, has submitted plans to the United States Government for the construction of a hydro-electric plant to develop about 200,000 hp. additional power; also the construction of a new dam across the Niagara River, 4 mi. below the falls. Total estimated cost, $50,000,000.

N. Y., Rockaway—The Lenith Amusement Co., 1579 Broadway, New York City, will install a steam heating system in the 1-story, 103 x 150 ft. theatre which it plans to build on the Boulevard west of Maneoke Ave. Total estimated cost, $100,000. T. W. Lamb, 644 8th Ave., New York City, Engr.

N. Y., Yonkers—The Ludlow Hotel Co., 290 South Broadway, will install a steam heating system in the 10-story, 90 x 217 ft. hotel which it plans to build on Ludlow St. and Broadway. Total estimated cost, $500,000. Roberts-Frost Co., 505 5th Ave., New York City, Engr.

N. J., Perth Amboy—The city plans to build a large pumping plant and install a water system. Estimated cost, $200,000.

Penn., Carlisle—E. B. Boetem & Sons, East Leuther St., will receive bids in the spring for the construction of a power house. Estimated cost, $50,000. A. J. Sauer & Co., c/o H. L. Shay, 130 South 15th St., Philadelphia, Engr.

Penn., Rutherford—The Philadelphia & Reading R. R., Reading Terminal, Philadelphia, plans to build a boiler house and machine shop. Total estimated cost, $45,000. S. T. Wagner, Ch. Engr.

Md., Baltimore—The City Water Department will expend $100,000 in 1919 for a 30,000,000 gallon pump to be installed at the Mt. Royal Pumping Station, North Ave. and McMechen St., and $7500 for a turbo-generator to be used in motorization of auxiliary units in the Mt. Royal Station. Walter E. Lee, Engr.

Md., Baltimore—The Poole Engineering & Machine Co., Woodberry St., plans to build a boiler house.

Va., Norfolk—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to rebuild the steam heating plant at the Norfolk Navy Yard, recently destroyed by fire entailing a loss of $30,000.

Va., Norfolk—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for installing mechanical stokers in the Navy Yard here; Specification No. 3586.

Va., Richmond—The Federal Reserve Bank, 1109 East Main St., plans to build a 5-story, 100 x 110 ft. bank and office building. A steam heating system will be installed in same. Total estimated cost, $350,000. Buckler & Fenhagen, 11 East Main St., Baltimore, Arch.

W. Va., Affinity—The Pemberton Coal & Coke Co. is receiving bids for the construction of a power plant. Noted Dec. 10.

W. Va., Charleston—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has had plans drawn for the installation of boilers and superheaters in the Navy Yard here. Estimated cost, $120,000.

W. Va., Moorefield—The city will soon award the contract for the construction of an electric-light plant. J. V. Shipley, Mayor.

Miss., Tutwiller—The City Clerk will receive bids until Dec. 30 for constructing and installing a small electric light plant. Estimated cost, $8000; noted Dec. 15.

S. C., Paris Island—The Bureau of Yards & Docks, Navy Department, Washington, D. C., is receiving bids for the construction of an addition to heating sytsem and power house here. Estimated cost, $97,000. C. W. Parks, Chief. Noted Dec. 3.

Ohio, Cleveland—The Cleveland Union Terminal Co. will install a steam heating system in the 20-story, 200 x 300 ft. railroad terminal and office building which it plans to build. Total estimated cost, $15,000,000. Barclay, Parsons & Clapp, 60 Wall St., New York City, N. Y., Engr.

Ohio, St. Marys—The city plans to build a new electric light plant.

Ohio, Youngstown—The Shenango Railway & Light Co. plans to build a power house. C. I. Crippen, 60 Broadway, New York City, N. Y., Mgr.

Ind., La Porte—The Great Western Manufacturing Co. plans to install a 500 kw. power plant, and is in the market for a boiler, turbo-generator, and all necessary equipment. C. C. Foutz, c/o owner, Engr.

Mich., Columbiaville—The taxpayers have voted $10,000 bonds for the construction of an electric-light and power plant.

Mich., Marquette—The Cleveland Cliffs Iron Works, Rockefeller Bldg., Cleveland, Ohio, plans to build a hydro-electric plant here. Arnold Co., 105 South La Salle St., Chicago, Ill., Engr.

Ill., Divernon—The municipal electric light plant was recently destroyed by fire, entailing a loss of $50,000.

Ill., Joliet—The power house of the Public Service Co. was recently completely destroyed by fire, entailing a loss of $500,000.

Ill., Malta—The city plans to install a larger engine in the electric-light plant. S. S. Plapp, Mgr.

Minn., Brainerd—A. M. Ahlborn, City Clerk, will receive bids in April for constructing a water supply system, to include concrete reservoir having a capacity of 800,000 gallons; brick pump house and plant; concrete tower and tank having a capacity of 300,000 gallons; digging of 2 or more wells and the laying of 13 mi. of cast iron pipe line. Estimated cost, $250,000. L. P. Wolf, 1000 Guardian Life Bldg., St. Paul, Engr.

Neb., Clarkson—The city will soon award the contract for rebuilding the power house. Estimated cost, $26,000. Henningson Engineering Co., 1122 Farnham St., Omaha, Engr.

S. D., Mitchell—The city has had plans prepared for improving the water-works plant, to include the construction of a new power house and sinking of 5 new soft water wells. The new plant will consist of a 40 x 100 ft. pumping station equipped with a 125 h.p. boiler and 1,500,000 gallon per hour pump. Total estimated cost, $71,000. S. Smith, City Engr.

Ga., Atlanta—The Georgia Railway & Power Co., Electric & Gas Bldg., plans to install two banks of three 1000 k.v.a. transformers at the Boulevard sub-station, increasing the capacity of Lindale line transformers to 6000 k.v.a., with extra transformers for each bank; extra transformers will also be installed at Newnan sub-station. G. W. Brine, Gen. Mgr.

Ky., Danville—The city plans the construction of a large power dam across Dix River, to furnish power for Danville, Lexington, Lancaster, Nicholasville and Richmond. Estimated cost, $1,000,000.

Mo., Halden—The Island Creek Coal Co. is in the market for two 400-h.p. boilers to be installed in the power plant.

Mo., Marshall—The city will receive bids in January for the construction of an electric-light plant. Henrici-Lowry Engineering Co., 222 Commerce Bldg., Kansas City, Engr.

Tex., Ft. Worth—The Gulf Well Machinery & Manufacturing Co., Dan Waggoner Bldg., plans to build a plant for the manufacture of oil-well machinery. Project includes a power house, forge shop, etc. Total estimated cost $225,000.

Okla., Ardmore—The Ardmore Street Railway Co., 15th and Wolverton St., plans to build a power plant in connection with the construction of an electric railway. I. M. Putnam, Gen. Mgr.

Ore., Marshfield—The C. A. Smith Co. will build extensions to its power house and install new equipment in same, by which power will be supplied to the Coos Bay and Coquille Valley districts. Total estimated cost, $50,000. A. G. Stearns, Gen. Mgr.

Cal., Los Angeles—The Water Department plans extensive improvements to its system during the first half of 1919. Plans include electrical pumping units to be installed in 2 pumping plants to cost $10,000, and the completion of the Haiwee power plant, $65,000.

Cal., Oroville—The Great Western Power Co., 14 Sansome St., San Francisco, plans to build a hydro-electric plant here. Herbert Fleishhacker, Vice-Pres.

Cal., Red Bluff—The city is having plans prepared by E. A. Rolinson, Engr., Redding, for the construction of a lighting system.

Ont., Toronto—The Department of Public Works, Ottawa, will soon award the contract for the construction of a boiler house, power plant, laundry, etc., R. C. Desrochers, Secy.

Man., Mapleton—The Manitoba Steel Foundry Co. plans to build a 1-story power house.

CONTRACTS AWARDED

Mass., Cambridge—Lever Bros. Co., 176 Broadway, has awarded the contract for the construction of a 5-story, 75 x 170 ft. addition to its factory, to Stone & Webster, 147 Milk St., Boston. A steam heating system will be installed in same. Total estimated cost, $500,000.

Penn., Pittsburgh—The Arsenal Theatre, 4100 Butler St., has awarded the contract for the construction of a boiler room, to James B. Clark, Westinghouse Bldg. Noted Dec. 3.

Va., Richmond—The U. S. Shipping Board has awarded the contract for the construction of two 100 x 150 ft. service buildings, to J. T. Wilson, Robinson and Broad St. A steam heating system will be installed in same. Total estimated cost, $100,000.

Kan., Kansas City—Wilson & Co., Osage and Adams St., has awarded the contract for the construction of a 3-story, 50 x 60 ft. power house, to the Fogel Construction Co., 515 Reliance Bldg.

Ore., Portland—The Emergency Fleet Corporation, Washington, D. C., has awarded the contract for the construction of 31 Scotch marine boilers, to the Willamette Iron & Steel Works, 462 North Front St. Estimated cost, $750,000.

N. S., Halifax—The Halifax Shipyards, Ltd., Barrington St., has awarded the contract for the construction of a 1-story, concrete power house, to the Bedford Construction Co., Bank of Commerce Bldg. Estimated cost, $60,000.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	$8.55
Buck.	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.20	2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

St. Louis—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10.

other rates p. 95.